ATMOSPHERIC DEPOSITION OF TOXIC SUBSTANCES TO THE GREAT LAKES: IADN RESULTS TO 1996

IADN

Integrated Atmospheric Deposition Network

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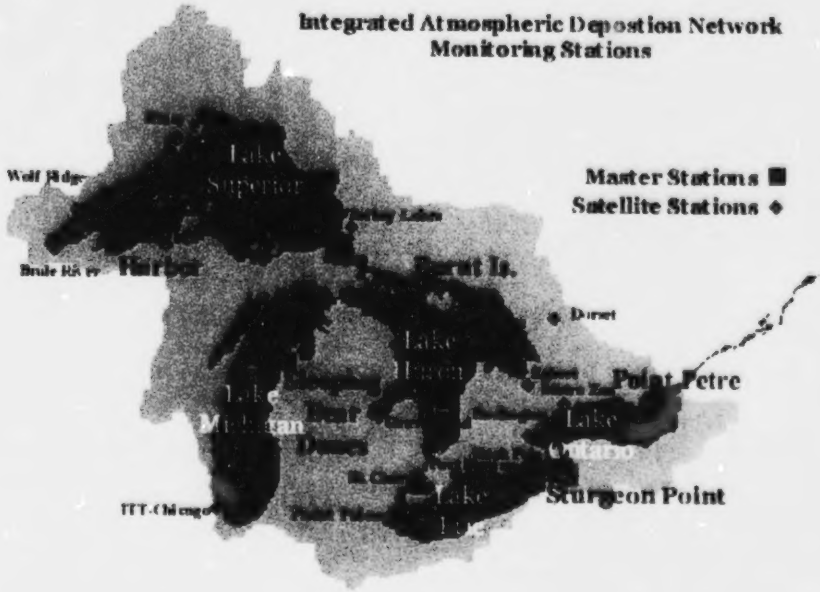
Map of the IADN Network



ATMOSPHERIC DEPOSITION OF TOXIC SUBSTANCES TO THE GREAT LAKES: IADN RESULTS TO 1996

Executive Summary

The primary objective of this document is to report biennial loadings estimates for the atmospheric deposition of toxic substances to the Great Lakes for the years 1995 to 1996. Atmospheric deposition is the phenomenon by which airborne substances are transferred to water, soil or vegetation at ground level. In IADN, three deposition processes to the Great Lakes are considered: wet deposition by precipitation, dry particle deposition by sedimentation, and net diffusive gas exchange that combines the effects of absorption from air to water with volatilisation from water to air.

The loading estimates presented herein are based on measurements taken largely at the IADN Master Stations, of which there is one per lake. Substances considered include those traditionally tracked by IADN,

- α- and γ-hexachlorocyclohexane, dieldrin, *p,p'*-DDE, *p,p'*-DDT, and *p,p'*-DDD
- hexachlorobenzene (HCB) and polychlorinated biphenyls expressed as ∑PCB and four individual PCBs: 18, 44, 52 and 101
- four polycyclic aromatic hydrocarbons (PAHs): phenanthrene, pyrene, benzo(k)fluoranthene, and benzo(a)pyrene
- four trace elements: lead, arsenic, selenium and cadmium,

as well as others reported here for the first time,

- *trans*- and *cis*-chlordane and *trans*-nonachlor
- α- and β-endosulphan and endosulphan sulphate
- an expanded suite of PAHs.

The loadings have been determined in a manner consistent with previous IADN reports, although refinements to the model include an update to the database of physicochemical parameters used in the calculations and the use of measured rather than estimated wind speeds. As a result of these refinements, loadings presented here are not strictly comparable to those presented in previous reports. In order to develop a uniform picture of network loadings over time, results have been recalculated for the period 1992-1994 using the same model assumptions and parameters as used for 1995-96. Temporal trends discussed in this report are based on those recalculated values.

In examining the loadings of toxic substances to the Great Lakes, three fundamental issues are considered: the magnitude of the loadings, the manner in which each loading component contributes to the total, and the variation or trends in the loadings across the basin and over many years. These loadings are presented in terms of fluxes (mass/unit area/unit time; *viz.* $ng/m^2/d$) in order to account for differences between lakes due to their areas.

Typical fluxes of banned organochlorine pesticides are on the order of 0.1 to 1 $ng/m^2/d$ and only regularly exceed 10 $ng/m^2/d$ for the gas exchange of α-HCH and dieldrin. Fluxes of individual PCB congeners tracked by IADN are typically between 0.1 and 1 $ng/m^2/d$ for each loading component, similar to many of the banned organochlorine pesticides, although seasonal volatilisation fluxes of ∑PCB can be higher than 50 $ng/m^2/d$. HCB gas exchange fluxes are in the 1 to 10 $ng/m^2/d$ range and fluxes of current-use pesticides γ-HCH and the endosulphans are on the order of 1 to 5 $ng/m^2/d$.

Inputs to the lakes of pesticides and PCBs are dominated by gas exchange and wet deposition. Dry particle concentration measurements ceased after 1995 due to low reported levels, but loading estimates presented here show that dry particle deposition of dieldrin, *p,p'*-DDD and PCBs may be significant when compared to the other deposition processes. Rates of dieldrin and ∑PCB volatilisation are greater than gas absorption so the lakes are acting as sources of these substances to the atmosphere.

Inputs of PAHs and metals are larger than those of pesticides and PCBs as expected by their continued emission to the environment. PAH fluxes range from 1 to 1000 $ng/m^2/d$ depending on species and loading process, and fluxes of trace metals reach values as high as 2000 $ng/m^2/d$. Since metals are non-volatile, they are subject only to wet and dry deposition with the wet fluxes typically being the larger of the two. Available data indicate that PAH volatilisation from the lakes is small compared to the other flux terms, and gas absorption is substantial for phenanthrene and pyrene while the higher molecular weight PAHs are delivered mostly by wet and dry particle deposition.

As part of its quality assurance program, IADN has begun a new set of intercomparison studies between its participating agencies. Until results are available, comparisons of depositional behaviour between lakes and over time have been limited to those situations where data were generated by the same operating agency.

Wet deposition fluxes are generally decreasing in time for the banned OC pesticides while dry deposition and gas exchange fluxes have been variable. The temporal trend in gas exchange is generally toward air-water equilibrium. For PCBs, wet deposition is steady in time while dry deposition was increasing before measurements ceased in 1995. Gas exchange of PCBs is in the direction of volatilisation from all lakes but is generally approaching air-water equilibrium.

Wet and dry particle deposition of PAHs show no consistent trends in time though levels increase from west to east across the basin. Little net gas exchange flux information is presented for PAHs since water concentration data are sparse. Deposition of metals is limited to wet and dry deposition with wet deposition declining in time and dry deposition being variable.

Loading estimates produced by IADN have traditionally been based on the assumption that Master Stations located at remote sites on the lakes are characterizing the regional

background deposition. However, strong inputs with more limited geographic influence are also likely to exist near cities and industrial areas. Using the case of Chicago on Lake Michigan as an example, data from 1996 were used to assess the impact of air pollution from urban centres on the deposition to the lakes. The IADN calculation was modified to include a small lake sub-area influenced by the high concentrations measured at Chicago and, though results should be viewed as lower-bound estimates when compared to other studies, deposition from Chicago sources is still estimated to be substantial for certain pesticides and PCBs and for all PAHs. Further work is needed to correctly characterize the lake area affected by urban air pollution and deduce effective ways of incorporating significant urban centres in IADN loading estimates.

IADN Loadings (kg/yr) From 1992 to 1996
Lake Superior

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	78	1.1	390	470
	1993	33	5.6	450	490
	1994	38	12	710	760
	1995	28	4.7	-230	-200
	1996	71	-	-240	-
γ-HCH	1992	62	0.65	140	200
	1993	14	2.7	47	64
	1994	19	2.4	95	120
	1995	9.5	1.9	65	76
	1996	38	-	43	-
dieldrin	1992	21	7.4	-500	-470
	1993	62	6.3	-540	-470
	1994	11	25	-500	-460
	1995	34	15	-240	-190
	1996	20	-	-200	-
p,p'-DDD	1992	-	6.1	-	-
	1993	17	0.1	-	-
	1994	10	-	-	-
	1995	0.89	0.5	-9.3	-7.9
	1996	0.8	-	4.3	-
p,p'-DDE	1992	2.6	0.39	-	-
	1993	3.8	1.2	-	-
	1994	4	-	-	-
	1995	4.6	0.96	-18	-12
	1996	2.1	-	-14	-
p,p'-DDT	1992	6.2	1.6	21	29
	1993	59	1.9	12	73
	1994	48	-	-	-
	1995	1.7	2.4	2	6.1
	1996	3.2	-	7.8	-
HCB	1992	5.3	0.67	47	53
	1993	25	19	15	59
	1994	1.2	0.37	16	18
	1995	1.5	0.42	24	26
	1996	1.2	-	22	-
PCB18	1992	0.92	0.26	-71	-70
	1993	3.1	0.39	-74	-71
	1994	1.6	2.9	-71	-67
	1995	2	1.9	-14	-10
	1996	3.4	-	14	-
PCB44	1992	1.4	0.45	-19	-17
	1993	9.1	0.92	-14	-4
	1994	1.7	2.8	-7.3	-2.8
	1995	2.2	1.7	-8.3	-4.4
	1996	1.9	-	51	-
PCB52	1992	1.1	0.31	-13	-12
	1993	1.8	0.56	-8	-5.6
	1994	2.1	3.1	5	10
	1995	2.6	2.4	-9.9	-4.9
	1996	2.6	-	34	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	1.7	0.45	-42	-40
	1993	1.6	0.74	-39	-37
	1994	1.6	2.3	-25	-21
	1995	3.1	1.4	-0.94	3.6
	1996	2.6	-	22	-
ΣPCB	1992	58	27	-1300	-1200
	1993	110	25	-1200	-1100
	1994	63	86	-1000	-850
	1995	70	47	-300	-180
	1996	90	-	-380	-
phenanthrene	1992	260	100	-5500	-5100
	1993	180	60	-6800	-6600
	1994	130	310	-6800	-6400
	1995	500	59	5700	6300
	1996	190	100	2200	2500
pyrene	1992	160	120	980	1300
	1993	140	74	67	280
	1994	210	220	-58	370
	1995	460	54	2600	3100
	1996	120	91	210	420
B(k)F	1992	120	52	140	310
B(k)F	1993	130	13	20	160
B(k)F	1994	92	58	70	220
B(b+k)F	1995	640	159	190	990
B(b+k)F	1996	219	152	98	470
B(a)P	1992	140	58	22	220
	1993	160	14	21	200
	1994	92	39	35	170
	1995	170	17	76	260
	1996	49	35	34	120
Pb	1992	-	-	-	-
	1993	-	16000	-	-
	1994	-	26000	-	-
	1995	-	-	-	-
	1996	-	-	-	-
As	1992	-	-	-	-
	1993	-	5600	-	-
	1994	-	2900	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Se	1992	-	-	-	-
	1993	-	1800	-	-
	1994	-	3100	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	2100	-	-
	1994	-	4400	-	-
	1995	-	-	-	-
	1996	-	-	-	-

IADN Loadings (kg/yr) From 1992 to 1996
Lake Michigan

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	62	1.5	52	120
	1993	44	4	81	130
	1994	98	6.3	120	220
	1995	56	4.5	350	410
	1996	15	-	300	-
γ-HCH	1992	65	1.1	870	940
	1993	120	2	250	370
	1994	47	1.4	490	540
	1995	26	2.2	190	220
	1996	6.6	-	110	-
dieldrin	1992	58	8	-	-
	1993	55	7.2	-	-
	1994	62	23	-	-
	1995	47	20	-	-
	1996	30	-	-	-
p,p'-DDD	1992	-	3.8	-	-
	1993	6.4	0.98	-	-
	1994	16	-	-	-
	1995	1.6	1.9	-	-
	1996	1.8	-	-	-
p,p'-DDE	1992	3.8	0.48	-	-
	1993	11	1.4	-	-
	1994	3.5	-	-	-
	1995	7.4	1.4	-	-
	1996	3.9	-	-	-
p,p'-DDT	1992	22	2.3	44	68
	1993	56	6.2	35	97
	1994	58	-	-	-
	1995	9.7	0.67	-	-
	1996	9	-	-	-
HCB	1992	2.6	0.38	24	27
	1993	13	13	1.2	27
	1994	1.1	0.19	-10	-8.7
	1995	1.4	0.35	8.3	10
	1996	0.91	-	8.3	-
PCB18	1992	0.91	0.18	-69	-68
	1993	1.3	0.46	-74	-72
	1994	1.6	1.2	-75	-72
	1995	2.6	1.1	-24	-20
	1996	1.7	-	-24	-
PCB44	1992	1.4	0.32	-44	-42
	1993	1.2	0.67	-42	-40
	1994	9.1	1.4	-52	-42
	1995	1.8	1.1	-20	-17
	1996	0.97	-	-22	-
PCB52	1992	1.2	0.24	-56	-55
	1993	1.1	0.55	-55	-53
	1994	2.3	1.4	-60	-56
	1995	3	2	3	8
	1996	2.2	-	2.2	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	1.4	0.33	-26	-24
	1993	0.81	0.66	-23	-22
	1994	1.7	1.1	-29	-26
	1995	2.1	1.6	-9.3	-5.6
	1996	1.4	-	-9.1	-
ΣPCB	1992	52	16	-1300	-1200
	1993	86	24	-1200	-1100
	1994	71	39	-1400	-1300
	1995	78	41	-330	-210
	1996	48	-	-320	-
phenanthrene	1992	350	110	-	-
	1993	230	100	-	-
	1994	160	160	-	-
	1995	360	82	-	-
	1996	220	100	-	-
pyrene	1992	220	140	-	-
	1993	220	140	-	-
	1994	130	170	-	-
	1995	340	95	-	-
	1996	140	110	-	-
B(k)F	1992	130	56	-	-
B(k)F	1993	110	43	-	-
B(k)F	1994	73	63	-	-
B(b+k)F	1995	480	198	-	-
B(b+k)F	1996	258	197	-	-
B(a)P	1992	170	77	-	-
	1993	170	42	-	-
	1994	77	63	-	-
	1995	160	37	-	-
	1996	84	41	-	-
Pb	1992	-	-	-	-
	1993	-	16000	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
As	1992	-	-	-	-
	1993	-	820	-	-
	1994	-	1300	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Se	1992	-	-	-	-
	1993	-	910	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	4500	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-

IADN Loadings (kg/yr) From 1992 to 1996
Lake Huron

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	170	-	-	-
	1993	140	-	-500	-
	1994	150	-	-490	-
	1995	220	-	-50	-
	1996	160	-	-63	-
γ-HCH	1992	-	-	-	-
	1993	260	-	-34	-
	1994	120	-	-19	-
	1995	110	-	32	-
	1996	93	-	29	-
dieldrin	1992	-	-	-	-
	1993	13	-	-760	-
	1994	15	-	-720	-
	1995	19	-	-	-
	1996	41	-	-	-
p,p'-DDD	1992	-	-	-	-
	1993	-	-	-	-
	1994	1.8	-	-	-
	1995	3.8	-	-	-
	1996	6.7	-	-	-
p,p'-DDE	1992	10	-	-	-
	1993	-	-	-	-
	1994	3.4	-	-	-
	1995	9.6	-	-	-
	1996	7.8	-	-	-
p,p'-DDT	1992	22	-	-	-
	1993	-	-	2.5	-
	1994	4.1	-	2.5	-
	1995	10	-	-	-
	1996	18	-	-	-
HCB	1992	5.8	-	-35	-
	1993	11	-	-14	-
	1994	3.3	-	-18	-
	1995	3.6	-	-35	-
	1996	1.3	-	-28	-
PCB18	1992	17	-	-	-
	1993	4	-	-28	-
	1994	0.94	-	-29	-
	1995	-	-	-14	-
	1996	-	-	-15	-
PCB44	1992	20	-	-	-
	1993	5.2	-	-10	-
	1994	2.5	-	-10	-
	1995	-	-	-17	-
	1996	-	-	-15	-
PCB52	1992	7.6	-	-	-
	1993	11	-	-6.8	-
	1994	2.6	-	-6.7	-
	1995	-	-	-7.3	-
	1996	-	-	-5.5	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	199[illegible]	11	-	-	-
	1993	6	-	0.77	-
	1994	1.9	-	0.74	-
	1995	-	-	-7.7	-
	1996	-	-	-6.1	-
ΣPCB	1992	180	-	-	-
	1993	130	-	-490	-
	1994	110	-	-460	-
	1995	-	-	-240	-
	1996	-	-	-230	-
phenanthrene	1992	-	-	-	-
	1993	640	90	-	-
	1994	320	71	-	-
	1995	250	63	-	-
	1996	390	110	-	-
pyrene	1992	-	-	-	-
	1993	350	130	-	-
	1994	190	77	-	-
	1995	220	61	-	-
	1996	350	130	-	-
B(k)F	1992	-	-	-	-
B(k)F	1993	-	83	-	-
B(k)F	1994	-	48	-	-
B(b+k)F	1995	610	-	-	-
B(b+k)F	1996	-	257	-	-
B(a)P	1992	-	-	-	-
	1993	-	110	-	-
	1994	-	56	-	-
	1995	350	-	-	-
	1996	-	100	-	-
Pb	1992	100000	11000	-	110000
	1993	64000	8000	-	72000
	1994	47000	11000	-	58000
	1995	15000	7600	-	23000
	1996	18000	13000	-	31000
As	1992	11000	2200	-	13000
	1993	7500	1700	-	9200
	1994	6500	1200	-	7700
	1995	2200	710	-	2900
	1996	2700	2900	-	5600
Se	1992	17000	2700	-	20000
	1993	12000	2400	-	14000
	1994	10000	2600	-	13000
	1995	2700	110	-	2800
	1996	3100	1100	-	4200
Cd	1992	6600	470	-	7100
	1993	2900	310	-	3200
	1994	2300	410	-	2700
	1995	1400	170	-	1600
	1996	2000	310	-	2300

IADN Loadings (kg/yr) From 1992 to 1996
Lake Erie

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	84	1.2	140	230
	1993	35	2	290	330
	1994	19	3.4	300	320
	1995	29	0.9	120	150
	1996	6.3	-	44	-
γ-HCH	1992	46	0.45	60	110
	1993	23	1.3	83	110
	1994	22	0.83	68	91
	1995	13	0.6	45	59
	1996	1.7	-	47	-
dieldrin	1992	28	5.6	-300	-270
	1993	32	3.7	-120	-84
	1994	8.9	18	-110	-83
	1995	12	11	-110	-87
	1996	9.4	-	-110	-
p,p'-DDD	1992	1.9	2	-	-
	1993	3.4	0.21	-	-
	1994	1.4	-	-	-
	1995	1.7	1.2	-	-
	1996	2	-	-	-
p,p'-DDE	1992	4.6	0.53	-	-
	1993	4.6	0.65	-	-
	1994	3.6	-	-	-
	1995	7.8	1.2	-	-
	1996	2.6	-	-	-
p,p'-DDT	1992	34	4.3	20	58
	1993	98	2.1	30	130
	1994	15	-	14	-
	1995	14	1.5	-	-
	1996	4.9	-	-	-
HCB	1992	0.88	0.2	-17	-16
	1993	5.4	6.4	0.76	13
	1994	0.4	0.21	-7	-6.4
	1995	0.73	0.22	-1	-0.05
	1996	0.34	-	-5.7	-
PCB18	1992	0.34	0.12	-17	-17
	1993	0.57	0.21	-15	-14
	1994	0.56	0.74	-15	-14
	1995	1.4	0.6	-22	-20
	1996	0.43	-	-26	-
PCB44	1992	0.55	0.23	-5.4	-4.6
	1993	0.81	0.43	-1.1	0.14
	1994	1.6	0.83	-5.2	-2.8
	1995	0.96	1.2	-11	-8.8
	1996	0.32	-	-16	-
PCB52	1992	0.42	0.28	-5.8	-5.1
	1993	0.729	0.33	-2.2	-1.1
	1994	1	0.85	-5.2	-3.4
	1995	1.7	1.3	-8.6	-5.6
	1996	0.65	-	-13	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	0.48	0.28	-2.2	-1.4
	1993	0.81	0.37	1	2.2
	1994	1.1	0.73	-2.6	-0.77
	1995	1.4	1.4	-5.2	-2.4
	1996	0.51	-	-6.6	-
ΣPCB	1992	21	16	-200	-160
	1993	26	14	-100	-60
	1994	41	29	-200	-130
	1995	58	32	-220	-130
	1996	18	-	-310	-
phenan-threne	1992	500	86	-	-
	1993	360	100	-	-
	1994	210	190	-	-
	1995	530	160	1600	2300
	1996	91	190	-770	-490
pyrene	1992	330	110	-	-
	1993	310	130	-	-
	1994	160	250	-	-
	1995	360	210	290	860
	1996	58	260	-80	240
B(k)F	1992	150	60	-	-
B(k)F	1993	140	84	-	-
B(k)F	1994	81	100	-	-
B(b+k)F	1995	560	580	52	1200
B(b+k)F	1996	158	430	15	600
B(a)P	1992	180	63	-	-
	1993	190	57	-	-
	1994	97	98	-	-
	1995	190	100	-0.75	290
	1996	50	120	-8	160
Pb	1992	-	-	-	-
	1993	-	13000	-	-
	1994	-	13000	-	-
	1995	-	-	-	-
	1996	-	-	-	-
As	1992	-	-	-	-
	1993	-	1500	-	-
	1994	-	1400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Se	1992	-	-	-	-
	1993	-	2800	-	-
	1994	-	2400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	1100	-	-
	1994	-	1500	-	-
	1995	-	-	-	-
	1996	-	-	-	-

IADN Loadings (kg/yr) From 1992 to 1996
Lake Ontario

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	52	-	-80	-
	1993	32	-	-54	-
	1994	33	-	-23	-
	1995	21	-	-5.7	-
	1996	31	-	-11	-
γ-HCH	1992	50	-	-8.2	-
	1993	37	-	-1.5	-
	1994	24	-	7.9	-
	1995	13	-	12	-
	1996	26	-	17	-
dieldrin	1992	11	-	-330	-
	1993	5.4	-	-200	-
	1994	3	-	-180	-
	1995	3.9	-	-230	-
	1996	4.5	-	-210	-
p,p'-DDD	1992	2.9	-	-	-
	1993	0.36	-	-	-
	1994	0.49	-	-	-
	1995	0.42	-	-	-
	1996	0.59	-	-	-
p,p'-DDE	1992	4.4	-	-96	-
	1993	2	-	-99	-
	1994	0.61	-	-80	-
	1995	5.3	-	-	-
	1996	2	-	-	-
p,p'-DDT	1992	3.3	-	4.4	-
	1993	7.2	-	5.5	-
	1994	1.1	-	8.2	-
	1995	14	-	-	-
	1996	4.1	-	-	-
HCB	1992	6.1	-	-170	-
	1993	3	-	-190	-
	1994	0.62	-	-150	-
	1995	0.73	-	-32	-
	1996	0.87	-	-28	-
PCB18	1992	2.5	-	-19	-
	1993	0.28	-	-22	-
	1994	0.35	-	-19	-
	1995	0.81	-	-18	-
	1996	0.71	-	-16	-
PCB44	1992	3.6	-	-19	-
	1993	5.7	-	-21	-
	1994	0.66	-	-18	-
	1995	2	-	-20	-
	1996	1.4	-	-19	-
PCB52	1992	1.6	-	-18	-
	1993	1.4	-	-22	-
	1994	0.93	-	-18	-
	1995	2.5	-	-11	-
	1996	2.5	-	-9.5	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	1.7	-	-1.6	-
	1993	2.3	-	-2.4	-
	1994	0.62	-	-0.84	-
	1995	1.8	-	-6.2	-
	1996	1.3	-	-5.4	-
ΣPCB	1992	56	-	-450	-
	1993	89	-	-570	-
	1994	15	-	-450	-
	1995	38	-	-230	-
	1996	26	-	-230	-
phenanthrene	1992	70	41	-510	-400
	1993	540	25	-	-
	1994	380	44	-	-
	1995	110	28	-	-
	1996	250	63	-	-
pyrene	1992	64	88	-46	110
	1993	470	55	-	-
	1994	220	48	-	-
	1995	130	46	-	-
	1996	260	83	-	-
B(k)F	1992	33	92	-9.7	120
B(k)F	1993	-	79	-	-
B(k)F	1994	-	29	-	-
B(b+k)F	1995	173	105	-	-
B(b+k)F	1996	311	249	-	-
B(a)P	1992	54	86	-	-
	1993	-	79	-	-
	1994	-	43	-	-
	1995	63	29	-	-
	1996	110	60	-	-
Pb	1992	40000	4500	-	45000
	1993	27000	5300	-	32000
	1994	15000	6100	-	21000
	1995	7600	3300	-	11000
	1996	5000	5100	-	10000
As	1992	2900	570	-	3500
	1993	3100	720	-	3800
	1994	2100	630	-	2700
	1995	970	210	-	1200
	1996	580	610	-	1200
Se	1992	5500	1000	-	6500
	1993	5000	1600	-	6600
	1994	3900	1800	-	5700
	1995	1300	150	-	1500
	1996	1100	340	-	1400
Cd	1992	2600	96	-	2700
	1993	1300	99	-	1400
	1994	550	130	-	680
	1995	530	49	-	580
	1996	390	100	-	490

DÉPÔT ATMOSPHÉRIQUE DE SUBSTANCES TOXIQUES DANS LES GRANDS LACS : RÉSULTATS DU RMDA JUSQU'EN 1996

Résumé

L'objectif premier de ce document consiste à signaler les estimations biennales de charges pour le dépôt atmosphérique des substances toxiques dans les Grands Lacs sur la période allant de 1995 à 1996. Le dépôt atmosphérique est le phénomène suivant lequel les substances en suspension dans l'air sont transférées dans l'eau, le sol ou la végétation au niveau du sol. Dans le RMDA, on examine trois processus de dépôts dans les Grands Lacs: dépôt humide par précipitations, dépôt de particules sèches par sédimentation et échange gazeux net de diffusion qui combine les effets de l'absorption de l'air à l'eau avec volatilisation de l'eau à l'air.

Les estimations de charges présentées ici reposent sur les mesures prises en grande partie aux stations principales du RMDA, à raison d'une de celles-ci par lac. Les substances examinées comprennent celles que suit traditionnellement le RMDA,

- α- et γ-hexachlorocyclohexane, dieldrine, *p,p'*-DDE, *p,p'*-DDT et *p,p'*-DDD
- hexachlorure de benzène (HCB) et polychlorobiphényles exprimés sous forme de ∑PCB et quatre PCB individuels : 18, 44, 52 et 101
- quatre hydrocarbures aromatiques polycycliques (HAP): phénanthrène, pyrène, benzo(k)fluoranthène et benzo(a)pyrène
- quatre éléments à l'état de traces : plomb, arsenic, sélénium et cadmium,

ainsi que d'autres signalés ici pour la première fois,

- *trans*- et *cis*-chlordane et *trans*-nonachlore
- α- et β-endosulphane et sulphate d'endosulphane
- une série étendue de HAP.

On a déterminé les charges d'une façon compatible avec les rapports antérieurs du RMDA, mais des améliorations du modèle comprennent une mise à jour de la base de données des paramètres physico-chimiques utilisés dans les calculs et l'utilisation des vitesses de vent mesurées plutôt qu'estimées. Par suite de ces raffinements, les charges présentées ici ne sont pas strictement comparables à celles que présentent les rapports précédents. Pour uniformiser la situation des charges du réseau dans le temps, on a recalculé les résultats pour la période 1992-1994 et utilisant les mêmes hypothèses et les mêmes paramètres de modèle que pour 1995-1996. Les tendances temporelles examinées dans ce rapport reposent sur les valeurs recalculées.

En examinant les charges de substances toxiques dans les Grands Lacs, on a abordé trois questions fondamentales: l'ampleur des charges, la façon dont chaque élément de charge contribue au total et la variation ou les tendances des charges dans le bassin et au cours de nombreuses années. Ces charges sont présentées sous forme de flux (masse/zone

unitaire/durée unitaire; c'est-à-dire ng/m^2/j), afin de tenir compte des différences entre les lacs du fait de leur zone.

Les flux types des pesticides d'organochlore interdits sont d'environ 0,1 à 1 ng/m^2/j et ne dépassent régulièrement 10 ng/m^2/j que pour l'échange gazeux de α-HCH et de dieldrine. Les flux des éléments congénères de PCB se situent en principe entre 0,1 et 1 ng/m^2/j par élément de charge, de façon analogue à bien des pesticides d'organochlore interdits, même si les flux de volatilisation saisonnière de $\sum$PCB peuvent être supérieurs à 50 ng/m^2/j. Les flux d'échange gazeux de HCB sont entre 1 et 10 ng/m^2/j et les flux de pesticides d'utilisation actuelle de γ-HCH et d'endosulphans se situent entre 1 et 5 ng/m^2/j.

L'apport de pesticides et de PCB dans les lacs est dominé par l'échange gazeux et le dépôt humide. Les mesures des concentrations de particules sèches ont cessé après 1995 du fait des faibles niveaux signalés, mais les estimations des charges présentées ici révèlent que le dépôt des particules sèches de dieldrine, de *p,p'*-DDD et de PCB peut être important par rapport aux autres processus de dépôt. La volatilisation de dieldrine et de $\sum$PCB est supérieure à l'absorption gazeuse, de sorte que les lacs servent de sources de ces substances à l'atmosphère.

Les apports de HAP et de métaux sont plus importants que ceux de pesticides et de PCB, comme on s'y attend du fait de leur émission continue dans l'environnement. Les flux de HAP se situent entre 1 à 1000 ng/m^2/j suivant les espèces et le processus de charge et les flux de métaux à l'état de traces atteignent jusqu'à 2000 ng/m^2/j. Comme les métaux ne sont guère volatils, il ne subissent qu'un dépôt humide et sec, les flux humides étant en principe les plus importants des deux types. Les données disponibles signalent que la volatilisation de HAP des lacs est faible par rapport aux autres termes de flux et que l'absorption gazeuse est substantielle pour le phénanthrène et du pyrène, alors que les HAP à poids moléculaire plus élevé sont acheminés surtout par le dépôt des particules humides et sèches.

En vertu de son programme d'assurance-qualité, le RMDA a commencé une nouvelle série d'études d'intercomparaison entre ses organismes participants. Jusqu'à ce que les résultats soient disponibles, les comparaisons du comportement de dépôt entre les lacs et dans le temps se sont limitées aux situations où les données ont été engendrées par le même organisme d'exploitation.

Les flux de dépôt humide baissent généralement dans le temps pour les pesticides d'OC interdits, alors que les flux du dépôt sec et de l'échange gazeux ont été variables. La tendance temporelle de l'échange gazeux s'oriente en général vers l'équilibre air-eau. Pour les PCB, le dépôt humide est régulier dans le temps, alors que le dépôt sec s'est accru avant que les mesures ne cessent en 1995. L'échange gazeux de PCB est dans l'orientation de la volatilisation sur tous les lacs, mais s'approche généralement de l'équilibre air-eau.

Le dépôt humide et de particules sèches de HAP ne révèle pas de tendances nettes dans le temps, même si les niveaux augmentent de l'ouest à l'est dans le bassin. On ne présente guère de renseignements sur les flux d'échanges gazeux nets, car les données de concentration en eau sont clairsemées. Le dépôt des métaux est limité aux dépôts humides et secs, les dépôts humides baissant dans le temps et le dépôt sec étant variable.

Les estimations de charges établies par le RMDA reposent traditionnellement sur l'hypothèse voulant que les stations principales situées aux stations reculées sur les lacs caractérisent le dépôt de fond régional. Toutefois, il est fort probable que de forts apports avec une influence géographique plus limitée existent près de villes et de zones industrielles. Si l'on cite l'exemple de Chicago sur le lac Michigan, on constate que les données de 1996 ont servi à évaluer l'effet de la pollution atmosphérique des centres urbains sur les dépôts survenant dans les lacs. On a modifié le calcul du RMDA, en incluant une région secondaire de petit lac influencée par les fortes concentrations mesurées à Chicago et, même si l'on doit voir dans les résultats des estimations de limite inférieure par rapport à d'autres études, le dépôt des sources de Chicago reste substantiel, d'après les estimations, pour certains pesticides et PCB et tous les HAP. Il faut d'autres travaux pour caractériser correctement la zone lacustre touchée par la pollution de l'air urbain et déduire des moyens efficaces d'incorporer les centres urbains aux estimations de charges du RMDA.

Charges (kg/an) du RMDA de 1992 à 1996
Lac Supérieur

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
α-HCH	1992	78	1.1	390	470
	1993	33	5.6	450	490
	1994	38	12	710	760
	1995	28	4.7	-230	-200
	1996	71	-	-240	-
γ-HCH	1992	62	0.65	140	200
	1993	14	2.7	47	64
	1994	19	2.4	95	120
	1995	9.5	1.9	65	76
	1996	38	-	43	-
dieldrine	1992	21	7.4	-500	-470
	1993	62	6.3	-540	-470
	1994	11	25	-500	-460
	1995	34	15	-240	-190
	1996	20	-	-200	-
p,p'-DDD	1992	-	6.1	-	-
	1993	17	0.1	-	-
	1994	10	-	-	-
	1995	0.89	0.5	-9.3	-7.9
	1996	0.8	-	4.3	-
p,p'-DDE	1992	2.6	0.39	-	-
	1993	3.8	1.2	-	-
	1994	4	-	-	-
	1995	4.6	0.96	-18	-12
	1996	2.1	-	-14	-
p,p'-DDT	1992	6.2	1.6	21	29
	1993	59	1.9	12	73
	1994	48	-	-	-
	1995	1.7	2.4	2	6.1
	1996	3.2	-	7.8	-
HCB	1992	5.3	0.67	47	53
	1993	25	19	15	59
	1994	1.2	0.37	16	18
	1995	1.5	0.42	24	26
	1996	1.2	-	22	-
PCB18	1992	0.92	0.26	-71	-70
	1993	3.1	0.39	-74	-71
	1994	1.6	2.9	-71	-67
	1995	2	1.9	-14	-10
	1996	3.4	-	14	-
PCB44	1992	1.4	0.45	-19	-17
	1993	9.1	0.92	-14	-4
	1994	1.7	2.8	-7.3	-2.8
	1995	2.2	1.7	-8.3	-4.4
	1996	1.9	-	51	-
PCB52	1992	1.1	0.31	-13	-12
	1993	1.8	0.56	-8	-5.6
	1994	2.1	3.1	5	10
	1995	2.6	2.4	-9.9	-4.9
	1996	2.6	-	34	-

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
PCB101	1992	1.7	0.45	-42	-40
	1993	1.6	0.74	-39	-37
	1994	1.6	2.3	-25	-21
	1995	3.1	1.4	-0.94	3.6
	1996	2.6	-	22	-
ΣPCB	1992	58	27	-1300	-1200
	1993	110	25	-1200	-1100
	1994	63	86	-1000	-850
	1995	70	47	-300	-180
	1996	90	-	-380	-
phenan-thrène	1992	260	100	-5500	-5100
	1993	180	60	-6800	-6600
	1994	130	310	-6800	-6400
	1995	500	59	5700	6300
	1996	190	100	2200	2500
pyrène	1992	160	120	980	1300
	1993	140	74	67	280
	1994	210	220	-58	370
	1995	460	54	2600	3100
	1996	120	91	210	420
B(k)F	1992	120	52	140	310
B(k)F	1993	130	13	20	160
B(k)F	1994	92	58	70	220
B(b+k)F	1995	640	159	190	990
B(b+k)F	1996	219	152	98	470
B(a)P	1992	140	58	22	220
	1993	160	14	21	200
	1994	92	39	35	170
	1995	170	17	76	260
	1996	49	35	34	120
Pb	1992	-	-	-	-
	1993	-	16000	-	-
	1994	-	26000	-	-
	1995	-	-	-	-
	1996	-	-	-	-
As	1992	-	-	-	-
	1993	-	5600	-	-
	1994	-	2900	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Se	1992	-	-	-	-
	1993	-	1800	-	-
	1994	-	3100	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	2100	-	-
	1994	-	4400	-	-
	1995	-	-	-	-
	1996	-	-	-	-

Charges (kg/an) du RMDA de 1992 à 1996
Lac Michigan

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
α-HCH	1992	62	1.5	52	120
	1993	44	4	81	130
	1994	98	6.3	120	220
	1995	56	4.5	350	410
	1996	15	-	300	-
γ-HCH	1992	65	1.1	870	940
	1993	120	2	250	370
	1994	47	1.4	490	540
	1995	26	2.2	190	220
	1996	6.6	-	110	-
dieldrine	1992	58	8	-	-
	1993	55	7.2	-	-
	1994	62	23	-	-
	1995	47	20	-	-
	1996	30	-	-	-
p,p'-DDD	1992	-	3.8	-	-
	1993	0.[illegible]	0.98	-	-
	1994	16	-	-	-
	1995	1.6	1.9	-	-
	1996	1.8	-	-	-
p,p'-DDE	1992	3.8	0.48	-	-
	1993	11	1.4	-	-
	1994	3.5	-	-	-
	1995	7.4	1.4	-	-
	1996	3.9	-	-	-
p,p'-DDT	1992	22	2.3	44	68
	1993	56	6.2	35	97
	1994	58	-	-	-
	1995	9.7	0.67	-	-
	1996	9	-	-	-
HCB	1992	2.6	0.38	24	27
	1993	13	13	1.2	27
	1994	1.1	0.19	-10	-8.7
	1995	1.4	0.35	8.3	10
	1996	0.91	-	8.3	-
PCB18	1992	0.91	0.18	-69	-68
	1993	1.3	0.46	-74	-72
	1994	1.6	1.2	-75	-72
	1995	2.6	1.1	-24	-20
	1996	1.7	-	-24	-
PCB44	1992	1.4	0.32	-44	-42
	1993	1.2	0.67	-42	-40
	1994	9.1	1.4	-52	-42
	1995	1.8	1.1	-20	-17
	1996	0.97	-	-22	-
PCB52	1992	1.2	0.24	-56	-55
	1993	1.1	0.55	-55	-53
	1994	2.3	1.4	-60	-56
	1995	3	2	3	8
	1996	2.2	-	2.2	-

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
PCB101	1992	1.4	0.33	-26	-24
	1993	0.81	0.66	-23	-22
	1994	1.7	1.1	-29	-26
	1995	2.1	1.6	-9.3	-5.6
	1996	1.4	-	-9.1	-
ΣPCB	1992	52	16	-1300	-1200
	1993	86	24	-1200	-1100
	1994	71	39	-1400	-1300
	1995	78	41	-330	-210
	1996	48	-	-320	-
phenanthrène	1992	350	110	-	-
	1993	230	100	-	-
	1994	160	160	-	-
	1995	360	82	-	-
	1996	220	100	-	-
pyrène	1992	220	140	-	-
	1993	220	140	-	-
	1994	130	170	-	-
	1995	340	95	-	-
	1996	140	110	-	-
B(k)F	1992	130	56	-	-
B(k)F	1993	110	43	-	-
B(k)F	1994	73	63	-	-
B(b+k)F	1995	480	198	-	-
B(b+k)F	1996	258	197	-	-
B(a)P	1992	170	77	-	-
	1993	170	42	-	-
	1994	77	63	-	-
	1995	160	37	-	-
	1996	84	41	-	-
Pb	1992	-	-	-	-
	1993	-	16000	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
As	1992	-	-	-	-
	1993	-	820	-	-
	1994	-	1300	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Se	1992	-	-	-	-
	1993	-	910	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	4500	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-

Charges (kg/an) du RMDA de 1992 à 1996
Lac Huron

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
α-HCH	1992	170	-	-	-
	1993	140	-	-500	-
	1994	150	-	-490	-
	1995	220	-	-50	-
	1996	160	-	-63	-
γ-HCH	1992	-	-	-	-
	1993	260	-	-34	-
	1994	120	-	-19	-
	1995	110	-	32	-
	1996	93	-	29	-
dieldrine	1992	-	-	-	-
	1993	13	-	-760	-
	1994	15	-	-720	-
	1995	19	-	-	-
	1996	41	-	-	-
p,p'-DDD	1992	-	-	-	-
	1993	-	-	-	-
	1994	1.8	-	-	-
	1995	3.8	-	-	-
	1996	6.7	-	-	-
p,p'-DDE	1992	10	-	-	-
	1993	-	-	-	-
	1994	3.4	-	-	-
	1995	9.6	-	-	-
	1996	7.8	-	-	-
p,p'-DDT	1992	22	-	-	-
	1993	-	-	2.5	-
	1994	4.1	-	2.5	-
	1995	10	-	-	-
	1996	18	-	-	-
HCB	1992	5.8	-	-35	-
	1993	11	-	-14	-
	1994	3.3	-	-18	-
	1995	3.6	-	-35	-
	1996	1.3	-	-28	-
PCB18	1992	17	-	-	-
	1993	4	-	-28	-
	1994	0.94	-	-29	-
	1995	-	-	-14	-
	1996	-	-	-15	-
PCB44	1992	20	-	-	-
	1993	5.2	-	-10	-
	1994	2.5	-	-10	-
	1995	-	-	-17	-
	1996	-	-	-15	-
PCB52	1992	7.6	-	-	-
	1993	11	-	-6.8	-
	1994	2.6	-	-6.7	-
	1995	-	-	-7.3	-
	1996	-	-	-5.5	-

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
PCB101	1992	11	-	-	-
	1993	6	-	0.77	-
	1994	1.9	-	0.74	-
	1995	-	-	-7.7	-
	1996	-	-	-6.1	-
ΣPCB	1992	180	-	-	-
	1993	130	-	-490	-
	1994	110	-	-460	-
	1995	-	-	-240	-
	1996	-	-	-230	-
phenanthrène	1992	-	-	-	-
	1993	640	90	-	-
	1994	320	71	-	-
	1995	250	63	-	-
	1996	390	110	-	-
pyrène	1992	-	-	-	-
	1993	350	130	-	-
	1994	190	77	-	-
	1995	220	61	-	-
	1996	350	130	-	-
B(k)F	1992	-	-	-	-
B(k)F	1993	-	83	-	-
B(k)F	1994	-	48	-	-
B(b+k)F	1995	610	-	-	-
B(b+k)F	1996	-	257	-	-
B(a)P	1992	-	-	-	-
	1993	-	110	-	-
	1994	-	56	-	-
	1995	350	-	-	-
	1996	-	100	-	-
Pb	1992	100000	11000	-	110000
	1993	64000	8000	-	72000
	1994	47000	11000	-	58000
	1995	15000	7600	-	23000
	1996	18000	13000	-	31000
As	1992	11000	2200	-	13000
	1993	7500	1700	-	9200
	1994	6500	1200	-	7700
	1995	2200	710	-	2900
	1996	2700	2900	-	5600
Se	1992	17000	2700	-	20000
	1993	12000	2400	-	14000
	1994	10000	2600	-	13000
	1995	2700	110	-	2800
	1996	3100	1100	-	4200
Cd	1992	6600	470	-	7100
	1993	2900	310	-	3200
	1994	2300	410	-	2700
	1995	1400	170	-	1600
	1996	2000	310	-	2300

Charges (kg/an) du RMDA de 1992 à 1996
Lac Erié

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
α-HCH	1992	84	1.2	140	230
	1993	35	2	290	330
	1994	19	3.4	300	320
	1995	29	0.9	120	150
	1996	6.3	-	44	-
γ-HCH	1992	46	0.45	60	110
	1993	23	1.3	83	110
	1994	22	0.83	68	91
	1995	13	0.6	45	59
	1996	1.7	-	47	-
dieldrine	1992	28	5.6	-300	-270
	1993	32	3.7	-120	-84
	1994	8.9	18	-110	-83
	1995	12	11	-110	-87
	1996	9.4	-	-110	-
p,p'-DDD	1992	1.9	2	-	-
	1993	3.4	0.21	-	-
	1994	1.4	-	-	-
	1995	1.7	1.2	-	-
	1996	2	-	-	-
p,p'-DDE	1992	4.6	0.53	-	-
	1993	4.6	0.65	-	-
	1994	3.6	-	-	-
	1995	7.8	1.2	-	-
	1996	2.6	-	-	-
p,p'-DDT	1992	34	4.3	20	58
	1993	98	2.1	30	130
	1994	15	-	14	-
	1995	14	1.5	-	-
	1996	4.9	-	-	-
HCB	1992	0.88	0.2	-17	-16
	1993	5.4	6.4	0.76	13
	1994	0.4	0.21	-7	-6.4
	1995	0.73	0.22	-1	-0.05
	1996	0.34	-	-5.7	-
PCB18	1992	0.34	0.12	-17	-17
	1993	0.57	0.21	-15	-14
	1994	0.56	0.74	-15	-14
	1995	1.4	0.6	-22	-20
	1996	0.43	-	-26	-
PCB44	1992	0.55	0.23	-5.4	-4.6
	1993	0.81	0.43	-1.1	0.14
	1994	1.6	0.83	-5.2	-2.8
	1995	0.96	1.2	-11	-8.8
	1996	0.32	-	-16	-
PCB52	1992	0.42	0.28	-5.8	-5.1
	1993	0.729	0.33	-2.2	-1.1
	1994	1	0.85	-5.2	-3.4
	1995	1.7	1.3	-8.6	-5.6
	1996	0.65	-	-13	-

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
PCB101	1992	0.48	0.28	-2.2	-1.4
	1993	0.81	0.37	1	2.2
	1994	1.1	0.73	-2.6	-0.77
	1995	1.4	1.4	-5.2	-2.4
	1996	0.51	-	-6.6	-
ΣPCB	1992	21	16	-200	-160
	1993	26	14	-100	-60
	1994	41	29	-200	-130
	1995	58	32	-220	-130
	1996	18	-	-310	-
phenanthrène	1992	500	86	-	-
	1993	360	100	-	-
	1994	210	190	-	-
	1995	530	160	1600	2300
	1996	91	190	-770	-490
pyrène	1992	330	110	-	-
	1993	310	130	-	-
	1994	160	250	-	-
	1995	360	210	290	860
	1996	58	260	-80	240
B(k)F	1992	150	60	-	-
B(k)F	1993	140	84	-	-
B(k)F	1994	81	100	-	-
B(b+k)F	1995	560	580	52	1200
B(b+k)F	1996	158	430	15	600
B(a)P	1992	180	63	-	-
	1993	190	57	-	-
	1994	97	98	-	-
	1995	190	100	-0.75	290
	1996	50	120	-8	160
Pb	1992	-	-	-	-
	1993	-	13000	-	-
	1994	-	13000	-	-
	1995	-	-	-	-
	1996	-	-	-	-
As	1992	-	-	-	-
	1993	-	1500	-	-
	1994	-	1400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Se	1992	-	-	-	-
	1993	-	2800	-	-
	1994	-	2400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	1100	-	-
	1994	-	1500	-	-
	1995	-	-	-	-
	1996	-	-	-	-

Charges (kg/an) du RMDA de 1992 à 1996
Lac Ontario

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
α-HCH	1992	52	-	-80	-
	1993	32	-	-54	-
	1994	33	-	-23	-
	1995	21	-	-5.7	-
	1996	31	-	-11	-
γ-HCH	1992	50	-	-8.2	-
	1993	37	-	-1.5	-
	1994	24	-	7.9	-
	1995	13	-	12	-
	1996	26	-	17	-
dieldrine	1992	11	-	-330	-
	1993	5.4	-	-200	-
	1994	3	-	-180	-
	1995	3.9	-	-230	-
	1996	4.5	-	-210	-
p,p'-DDD	1992	2.9	-	-	-
	1993	0.36	-	-	-
	1994	0.49	-	-	-
	1995	0.42	-	-	-
	1996	0.59	-	-	-
p,p'-DDE	1992	4.4	-	-96	-
	1993	2	-	-99	-
	1994	0.61	-	-80	-
	1995	5.3	-	-	-
	1996	2	-	-	-
p,p'-DDT	1992	3.3	-	4.4	-
	1993	7.2	-	5.5	-
	1994	1.1	-	8.2	-
	1995	14	-	-	-
	1996	4.1	-	-	-
HCB	1992	6.1	-	-170	-
	1993	3	-	-190	-
	1994	0.62	-	-150	-
	1995	0.73	-	-32	-
	1996	0.87	-	-28	-
PCB18	1992	2.5	-	-19	-
	1993	0.28	-	-22	-
	1994	0.35	-	-19	-
	1995	0.81	-	-18	-
	1996	0.71	-	-16	-
PCB44	1992	3.6	-	-19	-
	1993	5.7	-	-21	-
	1994	0.66	-	-18	-
	1995	2	-	-20	-
	1996	1.4	-	-19	-
PCB52	1992	1.6	-	-18	-
	1993	1.4	-	-22	-
	1994	0.93	-	-18	-
	1995	2.5	-	-11	-
	1996	2.5	-	-9.5	-

		Dépot humide	Dépot sec	Échange gazeux net	Dépot total
PCB101	1992	1.7	-	-1.6	-
	1993	2.3	-	-2.4	-
	1994	0.62	-	-0.84	-
	1995	1.8	-	-6.2	-
	1996	1.3	-	-5.4	-
ΣPCB	1992	56	-	-450	-
	1993	89	-	-570	-
	1994	15	-	-450	-
	1995	38	-	-230	-
	1996	26	-	-230	-
phenan-thrène	1992	70	41	-510	-400
	1993	540	25	-	-
	1994	380	44	-	-
	1995	110	28	-	-
	1996	250	63	-	-
pyrène	1992	64	88	-46	110
	1993	470	55	-	-
	1994	220	48	-	-
	1995	130	46	-	-
	1996	260	83	-	-
B(k)F	1992	33	92	-9.7	120
B(k)F	1993	-	79	-	-
B(k)F	1994	-	29	-	-
B(b+k)F	1995	173	105	-	-
B(b+k)F	1996	311	249	-	-
B(a)P	1992	54	86	-	-
	1993	-	79	-	-
	1994	-	43	-	-
	1995	63	29	-	-
	1996	110	60	-	-
Pb	1992	40000	4500	-	45000
	1993	27000	5300	-	32000
	1994	15000	6100	-	21000
	1995	7600	3300	-	11000
	1996	5000	5100	-	10000
As	1992	2900	570	-	3500
	1993	3100	720	-	3800
	1994	2100	630	-	2700
	1995	970	210	-	1200
	1996	580	610	-	1200
Se	1992	5500	1000	-	6500
	1993	5000	1600	-	6600
	1994	3900	1800	-	5700
	1995	1300	150	-	1500
	1996	1100	340	-	1400
Cd	1992	2600	96	-	2700
	1993	1300	99	-	1400
	1994	550	130	-	680
	1995	530	49	-	580
	1996	390	100	-	490

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1. Introduction

In response to growing concerns on the part of the International Joint Commission, a workshop investigating the role of atmospheric deposition in the delivery of toxic substances to the Great Lakes was held in Scarborough, Ontario, Canada in 1986. That workshop culminated in two major products: the first-ever collection of data and consequent development of loading estimates to the Lakes based on data from the 1980-1985 period (Strachan and Eisenreich, 1988) and the development of "The Plan" (Voldner and Eisenreich, 1987) aimed at improving those estimates in the future. Four years after that first report, an update to the loadings was prepared (Eisenreich and Strachan, 1992) in which many of the needed improvements called for in "The Plan" were implemented. Although IADN in its current form was taking shape, mass loading estimates were still available only for wet and dry particle deposition, with gas-particle partitioning in air determined by ascribing a temperature-dependent partitioning factor after the Junge-Pankow model (Junge, 1977; Pankow, 1987) rather than direct measurement. In 1996, the first set of loading estimates including gas exchange and using measured values of gas and particle-phase concentrations in air was published. (Hoff et al., 1996) This was followed by the first formal biennial loadings report for the period 1993-1994. (Hillery et al., 1998) The current report builds on these efforts and delivers results for data collected in 1995 and 1996.

The biennial reporting schedule for IADN is mandated by Annex 15 of the Canada-U.S. Great Lakes Water Quality Agreement. That annex describes two activities relating to airborne toxic substances: monitoring and surveillance for the estimation of loadings to the lakes, and research into atmospheric processes and sources of contaminants responsible for those loadings. These two activities are conducted separately even though some scientists and managers are involved in both. The present report addresses only the monitoring and surveillance component of Annex 15 and presents the scientific details of IADN's atmospheric loading estimates for 1995-96. Since pathways other than atmospheric deposition contribute to the entry of toxic substances to the lakes, the loadings estimates reported through IADN provide only part of the information needed to develop a complete understanding of toxic substances in the Great Lakes basin.

2. Methods

Loading estimates are calculated as the sum of three process-related terms: wet deposition, dry particle deposition, and net gas exchange. The latter is defined as the sum of an absorption term (from air to water, defined herein as positive gas exchange) and a volatilisation term (from water to air, defined herein as negative gas exchange). Each loading term is determined on an average seasonal basis after regular measurements of the various parameters of interest. An estimate of the variability associated with that average is also made.

2.1: Substances Considered

Loadings results have traditionally been reported through IADN for 20 substances. These are α- and γ–hexachlorocyclohexane, dieldrin, *p,p'*-DDE, *p,p'*-DDT, and *p,p'*-DDD, HCB, four PCBs: 18, 44, 52 and 101, as well as ∑PCB as estimated by each analytical laboratory, 4 PAHs: phenanthrene, pyrene, benzo(k)fluoranthene, and benzo(a)pyrene, and 4 trace elements: lead, arsenic, selenium and cadmium. The 1995-96 results reported here include those 20 substances and, in addition, loadings of *trans*- and *cis*-chlordane, *trans*-nonachlor, α- and β-endosulphan, endosulphan sulphate and an expanded suite of PAHs. The PAHs are those suggested for reporting under the UN ECE LRTAP Convention's 1998 Aarhus Protocol on Persistent Organic Pollutants: benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene. (UN ECE, 1998)

A modified suite of PCBs is also under development within IADN. This class of substances has presented a particular challenge to the network due to methodology differences between participating laboratories that result in variations in the individual PCBs reported and, consequently, the sum of PCBs calculated. The resulting suite is being designed to meet two criteria: (a) individual congeners in the suite are to be detected the majority of the time at the majority of sites, (b) the resulting ∑PCB is to represent a significant fraction of the calculated total of all measured congeners. At the time of writing, an initial suite of approximately 60 congeners is being tested for consistency across lakes and sampled media.

2.2: Calculation of Mass Flux and Corresponding Lake-wide Loading

The calculation method for IADN loadings has been described in detail elsewhere (Hoff 1994, Hoff et al. 1996, Hillery et al., 1998) and is only summarized here. The wet deposition estimate is the most straightforward, with the mass flux being the product of the volume-weighted mean concentration of the substance of interest in precipitation and the rate of precipitation. The dry deposition estimate is obtained by multiplying the concentration of the substance of interest associated with airborne particles by an assumed deposition velocity. The use of this constant deposition velocity is estimated to incorporate substantial error (Hoff, 1994), but available information on dry deposition has not yet been translated into an improved method for use in the network. Finally, the net gas exchange is calculated as the product of the mass transfer velocity and the concentration gradient between air and water as scaled by Henry's Law.

The gas exchange component of the total loading is estimated by use of a model describing diffusive transfer through thin films forming the interface between the bulk liquid of the lake water and the overlying air. (Schwarzenbach et al., 1993) Mass transfer coefficients (inverse resistances to transfer) are determined by taking established relationships for wind speed-dependent mass transfer of CO_2 to quantify the resistance in

the water phase and H_2O to quantify the resistance in the vapour phase (Hornbuckle, 1994), and adjusting for differences in diffusivities between the sample substance (CO_2 or H_20) and the toxic chemical of interest. In preparing the latest round of IADN results, and consequently updating the computer programs used in the calculations, it was seen that the methods used to determine those dimensionless multipliers can be significantly simplified compared to previously reported calculations of the same nature. The simplifications are presented in Appendix A.

2.3: Model Refinements for 1995-96

Three refinements were made to the IADN model for the calculation of results for 1995-96. Because of these changes, the Master Station loadings presented in the remainder of this report are not directly comparable to previously published results. An analysis of mass loadings over several years is presented in Section 3.2 and includes revised loadings for previous years calculated by the model as modified for 1995-96.

The first modification made was an update to the database of Henry's Law constants used in the calculation of gas exchange and, in particular, inclusion of recently determined temperature-dependent estimates. The values used are listed in Table 1.

H values were also updated for many PCB congeners in anticipation of the newly defined PCB suite. However, since the suite is still under development, these 1995-96 results use physico-chemical parameters for ∑PCB from previous calculations.

The second change made to the model was to use measured wind speeds in determining the gas exchange term of the fluxes rather than the constant wind speed of 5 m/s that was used in previous calculations. For 1995-96, those varied from 3 m/s to 5 m/s on an annual average basis. Such a variation has a significant effect on mass transfer estimates. For example, at 15°C and using the Henry's Law constants shown in Table 1 above, reducing the wind speed from 5 m/s to 3 m/s results in decreases in overall mass transfer coefficient for gas exchange with respect to water, k_{oL}, of 31% for B(k)F and 60% for PCB 101.

The final change made is a typographic correction to the coding involved in calculating the air-side mass transfer coefficient, k_a. That correction increases k_a by approximately 12% relative to previously published IADN values for all substances regardless of environmental conditions.

Table 1: HLCs used in IADN Calculation of Gas Exchange

Substance	Parameters *m* and *b* for Henry's Law Constant, H ($Pa \cdot m^3/mol$), $log_{10} H = m/T+b$		Source
	m	b	
α-HCH	-3054	10.1	Cotham and Bidleman (1991); Jantunen and Bidleman (2000)
dieldrin	-3416	12.2	Cotham and Bidleman (1991)
cis-chlordane	-3416	12.5	Iwata *et al.* (1995)
trans-chlordane	-3416	12.7	Iwata *et al.* (1995)
trans-nonachlor	-3416	13.2	Iwata *et al.* (1995)
p,p'-DDD	-3416	11.3	Suntio *et al.* (1987); Tateya *et al.*, (1988); as per Hoff *et al.* (1996)
p,p'-DDE	-3416	12.6	Iwata *et al.* (1995)
p,p'-DDT	-3416	11.7	Cotham and Bidleman (1991)
γ-HCH	-2694	8.54	Cotham and Bidleman (1991); Jantunen and Bidleman (2000)
α-endosulphan	-876	0.446	Rice *et al.* (1997)
β-endosulphan	-3416	8.18	Rice *et al.* (1997)
HCB	-2559	10.4	Ten Hulscher *et al.* (1992)
PCB 18 (tri)	-2611	10..4	Murphy *et al.* (1987); Ten Hulscher *et al.* (1992)
PCB 44 (tetra)	-2716	10.5	Murphy *et al.* (1987); Ten Hulscher *et al.* (1992)
PCB 52 (tetra)	-2716	10.4	Mackay *et al.* (1992); Ten Hulscher *et al.* (1992)
PCB 101 (penta)	-3416	12.9	Murphy *et al.* (1987); Ten Hulscher *et al.* (1992)
phenanthrene	-2469	8.89	Bamford *et al.* (1999)
pyrene	-2239	7.59	Bamford *et al.* (1999)
benzo[b]fluoranthene	-3416	10.4	Ten Hulscher *et al.* (1992)
benzo[k]fluoranthene	-3416	10.7	Ten Hulscher *et al.* (1992)
benzo[a]pyrene	-3416	10.8	Ten Hulscher *et al.* (1992)
indeno[1,2,3-cd]pyrene	-3416	6.95	Ten Hulscher *et al.* (1992)

2.4: Sources of Data

Concentration data for the vapour and particle fractions of air were obtained from measurements made every 12 days at each of the IADN Master Stations. At the Lake Huron and Ontario sites, each sample draws approximately 350 m^3 over 24 hours and at the Lake Superior, Michigan and Erie sites, 815 m^3 of air are sampled over the same time period.

Whole precipitation concentrations were determined at all Master Stations. Composite samples were collected every 14 days for Lake Huron and every 28 days at the other Master Stations.

Many of the meteorological data necessary to the determination of mass flux were collected on-site. Seasonal and annual statistics for wind speed and precipitation were computed for the entire season or year in question rather than the times when samplers were operating. Lake water surface temperatures, assumed to equal the temperature of the air film involved in air-water exchange, were obtained from the National Oceanic Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory (GLERL) satellite data. (NOAA, 1999) Annual meteorological data are presented in Table B1 of Appendix B.

All air and precipitation concentrations and meteorological data from IADN sites were submitted to quality control through the Research Data Management and Quality Control System™ (Sukloff et al., 1995) administered at the Centre for Atmospheric Research Experiments of Environment Canada.

Lake water concentrations are not measured directly in IADN. Rather, available data were pooled from cruises taken over recent years. Cruise data were available from the US R/V Lake Guardian cruise of the five lakes in spring 1996 as well as from CCGV Limnos cruises of Lakes Superior (1996), Erie (1995) and Ontario (1998). Some samples on the Limnos cruises were collected and analysed by two different agencies of Environment Canada: the National Water Research Institute and the Ecosystem Health Division of Ontario Region with some overlap of analytes. If more than one data source was available, pooling of concentration data was performed by weighting inversely by variance to account for different sample sizes and precisions. (Taylor, 1990) Final values are compiled in Table B2 of Appendix B. It is evident that lake concentration data useful to IADN loading estimates are sparse, and this problem has been identified in previous loading reports as well. (Hoff et al., 1996; Hillery et al., 1998) Where no values are available, no estimate of the volatilisation from lake water to air can be made. This is a serious detriment to the production of loading estimates since volatilisation is a significant process in the atmospheric cycling of most of these substances.

3. Results and Discussion

3.1: Master Station Loadings for 1995 and 1996

In examining the loadings of toxic substances to the Great Lakes, three fundamental issues are considered: the magnitude of the loadings, the manner in which each loading component contributes to the total, and the variation or trends in the loadings across the basin and over many years. The first two issues are considered in this section, and spatial and temporal trends are discussed separately in Section 3.3.

Although previous IADN reports have reported lakewide loadings (kg/yr), the following discussion is based on mass fluxes ($ng/m^2/d$) so that direct between-lake comparisons of the deposition can be conducted. To obtain the lakewide loading, the flux can simply be multiplied by the appropriate lake area and the resulting units converted from ng/d to kg/yr. The lake areas are 82,100 km^2, 57,800 km^2, 59,600 km^2, 25,700 km^2 and 18,960 km^2 for Lakes Superior, Michigan, Huron, Erie and Ontario, respectively As a result, the annual loading in kg/yr can be obtained by multiplying the annual mass flux in $ng/m^2/d$ by 30, 21, 22, 9.4 or 6.9.

Atmospheric loadings to the five Master Stations for 1995 and 1996 are presented in Appendix C in Tables C1 to C10. Each table is divided into 4 sub-tables (a-d) by chemical group: banned organochlorine pesticides, current-use pesticides, banned organochlorine commercial chemicals, and currently-emitted PAHs and metals.

The measured concentrations in air and precipitation exhibit marked variation over the annual cycle. As such, it is important to determine if the reported atmospheric loadings are likely different from zero. To do so, each loading term is assigned a coefficient of variation (COV) following the error propagation analysis conducted by Hoff (1994). Then, assuming the data are normally distributed, dry deposition and gas exchange loadings are said to be significantly different from zero if the reported COV is less than 267% for annual values and less than 120% for seasonal values. This result is based on a 95% confidence interval for annual sample sizes of 30 and seasonal sample sizes of 8. For wet deposition on Lake Huron, where samples are collected every 14 days, loadings are different from zero if the COV is less than 108% on a seasonal basis or 248% on an annual basis. For the other lakes, wet deposition is significantly different from zero if the COV is less than 40% on a seasonal basis or 165% annually.

A series of graphs depicting the relative magnitude of each loading component as fraction of the total input to the lake is presented in Appendix D. The total inputs in these graphs are normalized to 100% and represent the total "downward" loading from air to water. Gas exchange graphs include a negative component representing "upward" loading through volatilisation. The magnitude of the volatilisation term is expressed as a fraction of the net downward loading. If a negative loading component is greater than

100%, the lake under discussion is subject to net loss of contaminant to the atmosphere and is thus behaving as a contaminant source.

The amount of information generated by IADN is large. For example, 290 mass fluxes are presented for each lake each year in Appendix C alone. Since this document is aimed at reporting rather than exhaustive analysis, the following discussion will present a general overview of results and point out interesting features in the data. The loading values themselves are presented in the appendices for readers wanting a greater degree of detail.

3.1.1: Banned Organochlorine Pesticides

Typical values for annual fluxes of banned organochlorine pesticides are on the order of 0.1 to 1 $ng/m^2/d$ and only regularly exceed 10 $ng/m^2/d$ for gas exchange of α-HCH and dieldrin. The inputs are dominated by gas exchange on Lakes Superior and Ontario whereas wet deposition plays a significant role on the other lakes, particularly Lake Huron where wet deposition dominates delivery. For this group of substances, water data are available on all lakes only for α-HCH and *cis*- and *trans*-chlordane. In general, α-HCH and *cis*-chlordane are close to air-water equilibrium in Lakes Superior and Ontario while the other lakes are net recipients of these banned substances.

The behaviour of *trans*-chlordane is the most variable of this class of substances across the basin. In Lakes Superior and Michigan, levels are such that the water is a net recipient, but the balance is not far from air-water equilibrium. In Lake Ontario, the opposite is true, with volatilisation being about twice the net inputs. Lake Erie shows a net input situation but, unlike Lakes Superior and Michigan, it is far from air-water equilibrium. No *trans*-chlordane data are available for Lake Huron for either wet or dry particle deposition, but gas exchange shows about 2 times more volatilisation than absorption.

Dieldrin undergoes net volatilisation in all lakes for which water data exists, with outputs ranging from 3 to 4 times net inputs for Lakes Superior and Erie and more than 10 times net inputs for Lake Ontario. Inputs of dieldrin consist of a significant wet deposition component on all lakes. Except for Lake Superior, which was monitored during CCGV Limnos cruises, *p,p'*-DDT and its metabolites, *p,p'*-DDD and *p,p'*-DDE, can only be assessed on the input side since the available lake water data from the Lake Guardian cruises were judged unreliable by the originating lab. In general, inputs of the DDTs are comprised of significant fractions of wet deposition, dry particle deposition and gas absorption.

It is interesting to note that DDD has a substantial contribution by dry particles for Lakes Superior, Michigan and Erie in 1995. This cannot be assessed on other lakes or years due to a network-wide decision to abandon particle-phase analysis of air samples for the banned organochlorines. This decision may warrant re-evaluation given results presented

here for dieldrin, DDD and PCBs (see subsequent section on banned organochlorine commercial chemicals).

3.1.2: Current-use Pesticides

IADN's list of current-use pesticides is limited to γ-HCH and endosulphan. Daily fluxes of these pesticides are of the order of 1 to 5 $ng/m^2/d$. Lake water data are available for γ-HCH which, in all cases, is still being delivered to the lakes at a rate greater than its removal by volatilisation. That input is largely driven by gas absorption although wet deposition is important on Lake Ontario and even more so on Lake Huron. α-endosulphan is similar to γ-HCH in that its delivery to the lakes is dominated by gas absorption. Wet and dry deposition are more important in delivering β-endosulphan and endosulphan sulphate to the lakes than they are for α-endosulphan.

3.1.3: Banned Organochlorine Commercial Chemicals

This class of compounds includes hexachlorobenzene (HCB) and the polychlorinated biphenyls (PCBs). Average daily fluxes for individual reported PCB congeners are of the same order of magnitude as the banned organochlorine pesticides and fall between 0.1 and 1 $ng/m^2/d$ for each loading component. HCB in the gas phase tends to fall in the 1 to 10 $ng/m^2/d$ range and seasonal ∑PCB can be higher than 50 $ng/m^2/d$, albeit in the volatilisation direction. In general, it is the gas-phase processes of absorption and volatilisation that are dominating the atmospheric delivery of these substances to the lakes although wet deposition plays an important role on Lakes Michigan and Ontario. With the exception of Lake Superior, large volatilisation terms are leading to a net loss of PCBs from the lakes. HCB is close to air-water equilibrium in the lakes except Lakes Huron and Ontario where volatilisation is occurring.

As was the case for the banned organochlorine pesticides, PCB analysis of airborne particles ceased after 1995 for Lakes Superior, Michigan and Erie, and had ceased even earlier on Lakes Huron and Ontario. An examination of the PCB data presented for 1995 on Lakes Superior, Michigan and Erie shows that, even though particle-bound PCB concentrations may be low, the contribution made by dry deposition can be significant at 8% to 21% of the total downward loading.

3.1.4: Currently-Emitted PAHs and Metals

These substances are treated together because of their continued emission to the atmosphere in the Great Lakes region from a variety of industrial, transportation and residential sources. Mass fluxes of PAHs are variable with values in the 1 - 100 $ng/m^2/d$ range except for phenanthrene which exhibits gas exchange terms typically in the 100 - 1000 $ng/m^2/d$ range. Lake water data were available for Lakes Superior and Erie and volatilisation is small there compared to net downward fluxes. Inputs of phenanthrene

are dominated by gas absorption and pyrene is more evenly split between the downward deposition modes. The heavier PAHs are delivered mostly by wet and dry particle deposition.

Metals are measured only on Lakes Huron and Ontario. Fluxes of these substances are larger than those of most of the other substances in this report with values in the 100 $ng/m^2/d$ range for As, Se and Cd and close to 2000 $ng/m^2/d$ for Pb. Being relatively non-volatile, the atmospheric deposition of these substances is limited to wet and dry particle deposition with the former generally contributing more than half of the total downward flux.

3.2: Expanding Spatial Information beyond IADN Master Stations

The preceding results described mass fluxes based on measurements taken at one Master Station per lake. However, participating agencies operate other sites in the Great Lakes that are considered satellite stations in IADN. As a step toward exploring the spatial variation within lake basins as an indication of the representativeness of the Master Stations, annual average concentrations of some IADN chemicals measured at satellite stations were compared as presented in Appendix E.

Annual volume-weighted mean precipitation concentrations for 1996 are presented in Tables E1 and E2. There is good agreement between average annual concentrations measured on the same lake for sites operated by the same agency(all-substance average relative standard deviations of 21% to 54% depending on the lake in question) except for the large difference in concentrations measured on Lake Michigan as expected due to the urban location of the Chicago site. Agreement within a given lake basin declines when results from different agencies are compared; relative standard deviations of same-lake measurements by all agencies are 10% to 39% higher (RSD units) than those taken by only one agency.

Air measurements are compared in Tables E3, E4 and E5. Only Lake Superior has multiple sites operated by the same agency. As with precipitation, those within-agency results show good comparability with an all-substance average RSD of 32%. Unfortunately, it is not possible to conduct an inter-agency analysis to compare to the intra-agency result since no two agencies are measuring air the same way on any given lake.

In order to proceed with estimating the spatial variation within the lake basins, it is first necessary to quantify and adjust the differences that exist between the agencies in their measurements. With this goal, IADN is enhancing its quality assurance activities with a renewed set of field audits and laboratory intercomparisons already underway. Additionally, Indiana University is hosting a meeting of the IADN precipitation analytical chemists to review analytical protocols with the goal of harmonizing methodologies. Finally, all agencies involved in IADN are presently engaged in a side-

by-side intercomparison study at Point Petre to estimate total (sampling and analytical) variability among agencies.

3.3: Temporal and Spatial Trends in Master Station Loadings

Over recent years, scientists associated with IADN have conducted several studies examining the manner in which toxic substance concentrations in air and precipitation are changing with time. (Hillery et al., 1997; Cortes et al., 1998; Simcik et al., 1999; Cortes et al., 1999; Cortes et al., 2000; Simcik et al., 2000) Those studies have shown that the rates at which concentrations are decreasing are generally consistent between the atmospheric compartments and other media such as lake water and biota. Furthermore, a variety of techniques has successfully been applied to discriminate between continued local emission of a substance and its presence in the Great Lakes atmosphere through regional background or long-range transport. (Hoff et al., 1998; Cortes et al., 1999)

IADN's formal mandate goes beyond the characterisation of trends in atmospheric concentrations to the determination of trends in loadings to the lakes. The distinction arises from the fact that the exposure pathway for these contaminants is primarily through the aquatic food chain. Previous IADN reports have included estimates of changes in loadings to the lakes, (Eisenreich and Strachan, 1992; Hoff et al., 1996; Hillery et al., 1998) although interannual variability has been difficult to quantify with certainty.

Uniform quality control of IADN data and incorporation in a common database have only recently been achieved. As a result, it is possible for the first time to report results determined with consistent treatment of the data collected over the five years from 1992 to 1996 at all sites. Full results for the substances reported consistently since 1992 are presented in Appendix F with points of interest discussed in Sections 3.3.1-3.3.4.

Wet deposition and dry particle deposition can change in magnitude with time, but gas exchange can also change direction from net absorption to net volatilisation or vice versa. Since uncertainties in gas exchange can be particularly large near equilibrium, the fugacity ratio has been considered when describing temporal trends in gas exchange. As described by Mackay (1991), fugacity is a measure of the tendency of a substance to escape from the phase in which it resides; phases in equilibrium with each other have equal fugacities. Applying this concept to gas exchange leads to a fugacity ratio of unity being the descriptor of equilibrium between absorption and volatilisation. The ratio of gas exchange mass fluxes calculated by IADN is equivalent to the ratio of fugacities because the mass transfer coefficient is the same for the diffusive transport in both directions. All fugacity ratios are reported for air divided by water and are presented as fR_{year} (e.g. fugacity ratio in 1995 = fR_{1995}). A ratio greater than one indicates net absorption by the water and a ratio less than one indicates net volatilisation from the water to the air.

As a result of the lack of agreement between measurements conducted by different agencies operating sites on the same lake (see Section 3.2), results from Master Stations operated by different agencies on different lakes cannot be compared directly with confidence. As a result, comparisons in space and time should only be made for measurements made by the same agency. Air and precipitation measurements made on Lakes Superior, Michigan and Erie are comparable in space, but a change of analytical laboratory in 1994 makes results comparable in time over two distinct periods: from 1992-1994 and 1995-1996. Air measurements made on Lakes Huron and Ontario are comparable in space and over the entire period from 1992-1996. Over 1992-1994, precipitation measurements on Lakes Huron and Ontario were made by the same agency but a change occurred on Lake Huron in 1995. Therefore, results are fully comparable between the two lakes only from 1992-1994.

3.3.1: Organochlorine Pesticides

Annual wet deposition fluxes are generally decreasing in time for the OC pesticides, including lindane at sites in Canada where it is still used. The exceptions to this trend are dieldrin and the *p,p'*-DDT group whose wet deposition is increasing on Lake Huron. For the comparable sites at Lakes Superior, Michigan and Erie, wet deposition fluxes of the HCHs are lower at Lake Superior than at the other two lakes.

Information needed for the estimation of dry deposition fluxes of OC pesticides is only available on Lakes Superior, Michigan and Erie. At these sites, the airborne particle phase ceased to be analysed for OCs in 1995. Dry deposition fluxes of the HCHs are similar for all three lakes. Dieldrin values increase from west to east by a factor of 2. *p,p'*-DDD, *p,p'*-DDE and *p,p'*-DDT fluxes are only available for 1992 and 1995; they are similar on Lakes Superior and Michigan and higher on Lake Erie. A temporal comparison of these fluxes cannot be made since measurements were made by different agencies.

Gas exchange fluxes of OC pesticides are variable across the basin. This is reasonable given the complexity inherent in a flux term driven by the gradient between concentrations in air and lake water. In general, the temporal trend is toward air-water equilibrium although some substances appear to have reversed from one direction of air-water exchange to the other over 1992-1996. For example, γ-HCH on Lakes Huron (fR_{1992} not available, $fR_{1993} = 0.69$, $fR_{1996} = 1.94$) and Ontario ($fR_{1992} = 0.82$, $fR_{1996} = 1.89$) is now in net absorption. The gas exchange of dieldrin is in the direction of volatilisation for all lakes.

3.3.2: PCBs

Four congeners of PCBs are investigated (trichlorinated PCB18, tetrachlorinated PCB44 and PCB52, and pentachlorinated PCB101) in IADN as well as ∑PCB, and the behaviours of all five PCB parameters are generally similar to each other. In wet

deposition, the change in time is not steady except on Lake Huron, where fluxes decreased decisively until 1994 when the last PCB precipitation measurements were taken there. Wet deposition fluxes of $\sum$PCB are similar at the spatially comparable sites on Lakes Superior, Michigan and Erie.

Depositional fluxes for dry particle PCBs are available only for Lakes Superior, Michigan and Erie up to 1995. Particle deposition to these lakes generally increased from 1992-94, the period over which the same laboratory was analysing samples at those sites. Over all years, flux values are similar on Lakes Superior and Michigan and are approximately 50% higher on Lake Erie.

Gas exchange of $\sum$PCB is in the volatilisation direction on all lakes but approaching air-water equilibrium everywhere but Lake Erie, where the rate of volatilisation is steady and may be increasing. Individual congeners are generally behaving in a fashion similar to $\sum$PCB over time. The 4 IADN congeners appear to have reversed from volatilisation to absorption on Lake Superior as has PCB52 on Lake Michigan, but the apparent reversal takes place at the time of laboratory changeover on those lakes. PCB101 has reversed from absorption to volatilisation on Lakes Huron and Ontario (e.g. Ontario: $fR_{1992} = 1.3$, $fR_{1996} = 0.52$) although net flux values are small and therefore highly uncertain.

3.3.3: PAHs

Wet deposition of PAHs shows no consistent trends over the five years presented in Appendix F, and this is compatible with the fact that they continue to be emitted unlike other IADN substances that have been banned. Levels increase from west to east when looking at spatially comparable data for Lakes Superior, Michigan and Erie and for Lakes Huron and Ontario. Wet deposition is generally greater for phenanthrene and pyrene than it is for benzo(k)fluoranthene and benzo(a)pyrene, with the difference increasing from west to east.

The dry deposition of PAHs appears steady in time for same-agency time periods on Lakes Superior, Michigan and Huron. As with wet deposition, fluxes tend to increase from west to east across the basin. Dry deposition fluxes on Lake Erie are up to 5 times greater than those on Lake Superior.

Little gas exchange flux information is presented since water concentration data were available only on Lake Superior and Lake Erie, with Lake Superior being the only lake with 5 years of gas exchange flux estimates. The change in direction of gas exchange is different on the two lakes, with Lake Superior switching from volatilisation to absorption at the same time as the change in analytical laboratory for that site while Lake Erie phenanthrene gas exchange reversed from absorption to volatilisation between 1995 and 1996 ($fR_{1995} = 1.3$, $fR_{1996} = 0.84$). For pyrene, the direction and magnitude of the gas exchange is variable for both lakes. The air-water gas exchange of the heavier PAHs is considerably smaller than for phenanthrene and pyrene.

3.3.4: Metals

Deposition of metals is limited to wet and dry deposition. Five years of flux estimates are available only on Lakes Huron and Ontario and more limited information is available for the early years on the other lakes. The trend in time for wet deposition is decidedly downward with 1996 fluxes on Lake Ontario being 8 times lower for lead than 1992 values.

No consistent trend is evident from year to year for the dry deposition of metals. Depositional fluxes are higher on Lake Ontario than Lake Huron for Pb and Se and they are similar for As and Cd.

3.4: Applicability of IADN Method to Estimating Urban Impacts: Case of Chicago

Over recent years, several studies in the Great Lakes have shown that elevated concentrations of airborne toxic contaminants in urban areas are associated with higher-than-background deposition over adjacent waters. (Caffrey et al., 1996; Offenberg and Baker, 1997; Paode et al., 1998; Franz et al., 1998; Zhang et al., 1999; Offenberg and Baker, 1999) The IADN Master Stations were originally sited to capture only the regional background signal and therefore ignore large sources posited to have relatively limited geographic influence. Since the characterization of such sources was deemed necessary to the original long-term design of the network, (Voldner and Eisenreich, 1987) this report assesses whether the IADN approach can be used to estimate the significance of these concentrated inputs to the lakes.

A full assessment of urban impacts to the Great Lakes would have to consider densely populated regions such as those at Chicago, Detroit/Windsor, Cleveland, Buffalo/Niagara Falls, Hamilton and Toronto. IADN has only one satellite station in an urban area (IIT-Chicago) so loadings estimates have been prepared for 1996 data collected at IIT and at Sleeping Bear Dunes (SBD), IADN's Master Station on Lake Michigan. This comparison is not intended as an evaluation of the total urban impact to Lake Michigan but rather as a first step in using IADN's existing infrastructure to gain information about urban impacts on atmospheric deposition.

To begin, the relative magnitudes of the estimated fluxes at the two sites are compared as if they occurred, undiminished, just over adjacent waters. Then, those results are extrapolated to loadings over the lake by accounting for factors such as area of influence of the urban plume.

Water concentration data were unavailable for Lake Michigan for dieldrin, *p,p'*-DDT and metabolites, and the PAHs. In order to determine volatilisation fluxes, data from other lakes were used as estimates. *p,p'*-DDT water concentrations were taken from Lake Superior as it was the only lake with available data. For dieldrin and the PAHs, the

higher Lake Erie data were used in order to develop conservative estimates of net downward deposition by maximising the estimated volatilisation flux. The average lakewide water surface temperature was used for both SBD and Chicago.

Results are presented in Table 2. As one would expect from the elevated concentrations measured in Chicago, depositional mass fluxes from Chicago air are elevated relative to the background site. This is true for every compound and every deposition process except *cis*-chlordane in wet deposition though Chicago values for that compound and process demonstrated atypically large variability. All substances that show net volatilisation at the regional background site show net absorption near Chicago. The reversal in gas exchange is driven by the elevated gas-phase concentrations in Chicago air which overcome the increased volatilisation there due to higher wind speeds relative to SBD.

Although it seems logical that polluted atmospheres on the shores of the lakes will induce enhanced depositional fluxes to waters adjacent to overland sources, a further step must be taken to determine if those enhanced fluxes are significant on a lake-wide basis. Evaluating the latter issue requires that the mass fluxes measured at the overland sites be extended to the entire lake surface beyond the immediate proximity of the shoreline.

In their work on gaseous PCB fluxes from Chicago to Lake Michigan, Zhang *et al.* (1999) estimated that the "urban plume" affects as much as the entire southern quarter of the lake while other studies have used more conservative estimates of 5% or less. (Offenberg and Baker, 1997; Franz et al., 1998) Measurements have shown that air and precipitation concentrations are lower over the lake than they are in Chicago, even when airflow originates in the urban area. (Offenberg and Baker, 1997; Simcik et al., 1997; Paode et al., 1998; Franz et al., 1998) For the IADN estimates, it was desired to keep the calculation simple by assigning a sub-area within the lake over which the elevated concentrations measured in Chicago could be assumed to hold and beyond which they immediately dropped to background levels as measured at SBD. Naturally, this sub-area would be smaller than the estimated plume effect area to compensate for the higher input concentration being used in the mass loading calculation. A rectangular sub-area bounded by 100km of shoreline and 10 km of adjacent water for wet and dry deposition and 20 km for gas exchange was selected. This corresponds to wet and dry particle deposition areas of 1,000 km^2 (1.7% of total lake area) and a gas exchange area of 2,000 km^2 (3.5% of total lake area).

Not only does the lake area need to be divided to assess the effect of Chicago, but a temporal modification needs to be made as well. The IADN loading calculation normally uses the Master Station data as representative of typical conditions over the entire lake regardless of the direction of airflow. This approach does not translate directly to examining a particular source. Instead, a "time of influence" has to be devised so that only those times when the airflow is moving from the city to the water are considered for the urban influence. By examining the hourly meteorological observations made at the

Table 2: Mass Fluxes (ng/m^2/d) of Atmospheric Deposition at Sleeping Bear Dunes Master Station (SBD) and Chicago.

Species	Wet Deposition		Dry Deposition		Gas Exchange						Total Mass Flux	
					Gas Absorption		Volatilisation		Net Gas Exchange			
	SBD	Chicago	SBD	Chicago	SBD	Chicago	SBD	Chicago	SBD	Chicago	SBD	Chicago
a-HCH	0.71	3.2	-	-	19	38	-4.9	-6	14	32	15	35
dieldrin	1.4	4.2	-	-	1.9	24	-12	-17	-10	6.5	-8.6	11
cis-chlordane	0.18	0.11	-	-	0.52	6.6	-0.68	-1	-0.15	5.6	0.03	5.7
trans-chlordane	0.45	1.5	-	-	0.36	5.9	-0.51	-0.78	-0.14	5.1	0.31	6.6
trans-nonachlor	0.045	0.46	-	-	0.11	1.5	-0.82	-1.4	-0.7	0.1	-0.66	0.56
DDD	0.084	0.38	-	-	0.34	0.93	-0.12	-0.15	0.22	0.78	0.3	1.2
DDE	0.19	1.3	-	-	0.62	5.5	-0.75	-1.1	-0.13	4.4	0.06	5.7
DDT	0.43	3.9	-	-	0.61	8	-0.35	-0.44	0.26	7.6	0.69	12
g-HCH	0.31	2.9	-	-	5.9	15	-0.78	-0.95	5.1	14	5.4	17
a-endosulphan	0.65	1.4	-	-	17	22	-0.033	-0.039	17	22	18	23
b-endosulphan	0.37	1.3	-	-	1.7	1.9	-0.00095	-0.0011	1.7	1.9	2.1	3.2
endosulphan sulphate	0.33	24	-	-	-	-	-	-	-	-	-	-
HCB	0.043	0.11	-	-	2.2	5.9	-1.9	-3.2	0.39	2.6	0.43	2.7
PCB18	0.08	0.24	-	-	0.18	4.2	-1.3	-2.2	-1.1	2	-1	2.2
PCB44	0.046	0.27	-	-	0.21	8.7	-1.3	-2.1	-1	6.7	-0.95	7
PCB52	0.1	0.38	-	-	0.31	8.6	-0.21	-0.33	0.1	8.3	0.2	8.7
PCB101	0.064	0.44	-	-	0.16	5.4	-0.59	-0.94	-0.43	4.4	-0.37	4.8
Sum-PCB	2.3	13	-	-	4.4	130	-20	-33	-15	97	-13	110
PHEN	10	330	5	180	140	18000	-480	-670	-340	17000	-330	18000
PYR	6.8	400	5.1	340	12	2200	-57	-73	-45	2100	-33	2800
B(b+k)F	12	390	9.2	340	4.1	71	-1.6	-1.9	2.6	70	24	800
B(a)P	4	210	1.9	130	1.5	19	-1.7	-2	-0.12	17	5.8	360
I(1,2,3-cd)P	6.3	230	4.8	180	0.96	23	-0.00037	-0.00044	0.96	23	12	430
Sum-PAH (UN ECE)	23	840	16	650	6.7	110	-3.2	-3.9	3.4	110	42	1600

* Mass fluxes have been calculated directly from measurements at the overland sites at SBD and Chicago. Volatilisation estimates are based on average water concentrations in Lake Michigan; they differ due to the use of meteorological data specific to each site.

Chicago site, it was determined that winds were from the southwest only 32% of the time in 1996. The use of Chicago wind speeds as estimates over the adjacent water is justified by the fact that wind speeds measured from a tower anchored on a drinking water intake crib 15-km off shore from Chicago were comparable to those measured at the permanent air monitoring site on land. (Zhang *et al.*, 1999)

Adjusting the fluxes found in Table 2 in accordance with the conditions stated above results in the annual mass loadings presented in Table 3. The percent increases in lakewide loading due to inclusion of the urban input (termed the urban effect) are also included in the table, and negative values indicate that net background lakewide volatilisation is reduced by including high inputs from Chicago.

Since IADN's mandate is to determine loadings on a lakewide basis, the network can justifiably ignore an urban influence if it is small compared to the lakewide background estimates normally calculated from Master Station data. Results in Table 3 show that wet deposition of pesticides and banned commercial chemicals over the small lake area near Chicago is not having a large lakewide effect. The one exception to this observation is for endosulphan sulphate whose elevated precipitation concentration at Chicago serves to increase the total lakewide loading by 50%. Dry particle deposition for these substances cannot be assessed because airborne particle concentrations were not measured in 1996. For gas exchange, the urban effect is more pronounced than for wet deposition, with Chicago contributing substantially to lakewide loadings for *cis*- and *trans*-chlordane, *p,p'*-DDE and *p,p'*-DDT, and PCB 52. Combining the influence of all deposition processes leads to large overall lakewide urban effects for *cis*-chlordane, DDE and PCB 52 originating in Chicago air.

The urban plume loadings for PAHs are so much larger than background values that current emissions from Chicago are substantial for all modes of deposition, even with the reduced lake area and time of influence of the city used in the estimates. For wet and dry particle deposition, lakewide loadings are increased by 20% to 40% when accounting for urban inputs. For gas exchange, results are even more dramatic, with net volatilisation of the more volatile PAHs, phenanthrene and pyrene, being reduced by more than 50%. The overall effect of Chicago-generated PAHs is to increase total mass loadings of the less volatile PAHs by 20% to 40%, to cut phenanthrene's net volatilisation in half, and to bring the entire lake close to air-water equilibrium for pyrene.

The preceding discussion relies on the assumption that these IADN estimates obtained by measuring urban concentrations and extending them to a small over-lake area are reasonable. Recent studies on Lake Michigan have examined the effect of the Chicago area's urban plume on depositional loadings. (Offenberg and Baker, 1997; Franz et al., 1998; Zhang et al., 1999) The drawback of these studies has typically been the small number of measurements taken over short time periods relative to IADN's regular, long-term measurements. These other studies have also incorporated rough assumptions about

Table 3: Lakewide Loadings to Lake Michigan: Effect of Adding Loadings from Chicago to Master Station Estimates of Regional Background (BG) Loadings.

Species	Wet Deposition			Dry Deposition			Net Gas Exchange			Total Mass Loading		
	BG (kg/yr)	Chicago (kg/yr)	Urban Effect	BG (kg/yr)	Chicago (kg/yr)	Urban Effect	BG (kg/yr)	Chicago (kg/yr)	Urban Effect	BG (kg/yr)	Chicago (kg/yr)	Urban Effect
a-HCH	15	0.41	2.7%	-	-	-	300	8	2.7%	320	8.4	2.6%
dieldrin	30	0.52	1.7%	-	-	-	-220	1.6	-0.7%	-190	2.1	-1.1%
cis-chlordane	3.9	0.012	0.3%	-	-	-	-3.3	1.3	-39.4%	0.6	1.3	216.7%
trans-chlordane	9.6	0.16	1.7%	-	-	-	-3	1.2	-40.0%	6.6	1.4	21.2%
trans-nonachlor	0.95	0.064	6.7%	-	-	-	-15	0.023	-0.2%	-14	0.087	-0.6%
p,p'-DDD	1.8	0.05	2.8%	-	-	-	4.7	0.2	4.3%	6.5	0.25	3.8%
p,p'-DDE	3.9	0.16	4.1%	-	-	-	-2.7	1	-37.0%	1.2	1.2	100.0%
p,p'-DDT	9	0.53	5.9%	-	-	-	5.6	1.8	32.1%	15	2.3	15.3%
g-HCH	6.6	0.34	5.2%	-	-	-	110	3.2	2.9%	120	3.5	2.9%
a-endosulphan	14	0.16	1.1%	-	-	-	360	5	1.4%	370	5.2	1.4%
b-endosulphan	7.7	0.15	1.9%	-	-	-	36	0.41	1.1%	44	0.56	1.3%
endosulphan sulphate	7	3.7	52.9%	-	-	-	-	-	-	-	-	-
HCB	0.91	0.014	1.5%	-	-	-	8.3	0.66	8.0%	9.2	0.67	7.3%
PCB18	1.7	0.029	1.7%	-	-	-	-24	0.45	-1.9%	-22	0.48	-2.2%
PCB44	0.97	0.033	3.4%	-	-	-	-22	1.4	-6.4%	-21	1.4	-6.7%
PCB52	2.2	0.047	2.1%	-	-	-	2.2	1.9	86.4%	4.4	1.9	43.2%
PCB101	1.4	0.056	4.0%	-	-	-	-9.1	0.98	-10.8%	-7.7	1	-13.0%
Sum-PCB	48	1.6	3.3%	-	-	-	-320	22	-6.9%	-270	24	-8.9%
PHEN	220	46	20.9%	100	23	23.0%	-7200	3800	-52.8%	-6900	3900	-56.5%
PYR	140	57	40.7%	110	43	39.1%	-950	500	-52.6%	-700	600	-85.7%
B(b+k)F	258	53	20.5%	197	42	21.3%	55	18	32.7%	510	110	21.6%
B(a)P	84	29	34.5%	41	15	36.6%	-2.4	4.6	-191.7%	120	49	40.8%
I(1,2,3-cd)P	130	32	24.6%	100	22	22.0%	20	6.3	31.5%	250	60	24.0%
Sum-PAH (UN ECE)	480	110	22.9%	340	79	23.2%	72	29	40.3%	890	220	24.7%

the area influenced by the urban plume and they have operated with spatial coverage that is only marginally better than the two sites used by IADN.

Results from these studies are compared in Table 4, where it can be seen that IADN estimates of urban-source deposition are lower than those reported elsewhere. For dry deposition of PAHs, IADN loadings are 30%-70% those estimated by Franz et al. (1998), who used smaller fluxes measured over water and a relatively larger lake area assumed to be influenced by the plume. IADN's gas exchange estimates for PCBs are only 16% of those estimated by Zhang et al. (1999), who assumed that a large portion of the lake (25%) was affected by the urban plume. For wet deposition of PCBs, it appears that the events sampled during the short study reported (Offenberg and Baker, 1997) were not representative of average values. That study reported a volume-weighted mean concentration of PCBs in Chicago rainwater of 29.3 ng/L compared to the annual IADN average of 3.46 ng/L for 1996, the only Chicago data year available in IADN. Using the summer storm data reported by Offenberg and Baker (1997) may lead to overestimates of the annual average lakewide effect of wet deposition of PCBs originating in Chicago.

Table 4: Comparison of Additional Loading to Lake Michigan (kg/yr) due to Air from Chicago as Calculated by IADN and Other Studies

Substance	**Deposition Type**	**Urban Loading Estimate (kg/yr)**		
		IADN	**Comparison Study**	**Comparison Source and Comments**
PAHs	Dry particle	*Phenanthrene* 23 *Pyrene* 43 *UN ECE 4* 79	*Phenanthrene* 75 *Pyrene* 62 *UN ECE 4* 114	Franz et al., 1998 • lake area used is 2.6% vs. 1.7% in IADN • individual PAH loadings estimated by pro-rating published ΣPAH fluxes by mass weights presented later in same publication
PCBs	Gas exchange	22	140	Zhang et al., 1999 • limited AEOLOS sampling extended to a full year model set • estimated fluxes (35 ug/m^2/yr IADN at Chicago, 9 ug/m^2/yr for AEOLOS over-water) are consistent with observed AEOLOS decrease of 69% in concentration from Chicago to over-water sites • lake area used is 25% vs. 3.5% for IADN
PCBs	Wet	1.6	50	Offenberg and Baker, 1997 • AEOLOS results for small number of precipitation events; IADN long-term concentrations much lower • lake area used is 5% vs. 1.7% for IADN

In light of these results and the uncertainty behind loading calculations extrapolated from limited measurements of concentration or mass flux, it appears that the IADN estimates produce results about the urban impact that are low when compared to other reported studies. Nonetheless, the results are reasonable given that they are comparable in terms of order of magnitude and reflect the differences that might be expected for IADN's consideration of Chicago versus the other studies focus on the entire urban area on the southern shores of Lake Michigan. IADN values should be viewed as lower-bound estimates at this time, providing a conservative assessment of the effect of one urban centre's air pollution on the adjacent lake's loadings of toxic substances.

Even with the conservative nature of the loadings produced by this exercise, IADN's results show that an urban centre can have a significant impact on atmospheric deposition to an adjacent lake. This is true for certain banned pesticides and PCBs as well as all tested PAHs. The scenario reported here estimated the effect of only one urban centre and, in reality, that effect would likely be increased on lakes with many cities along their shores. Given current resources, further work is needed to determine an effective way for IADN to account for urban sources in its loading estimates without greatly increasing the number of routine measurements made in the network.

4. Conclusions

In examining the loadings of toxic substances to the Great Lakes, three fundamental issues are considered: the magnitude of the loadings, the manner in which each loading component contributes to the total, and the variation or trends in the loadings across the basin and over many years.

For 1996-96, typical fluxes of banned organochlorine pesticides are on the order of 0.1 to 1 ng/m^2/d and only regularly exceed 10 ng/m^2/d for the gas exchange of α-HCH and dieldrin. Fluxes of individual PCB congeners are typically between 0.1 and 1 ng/m^2/d for each loading component, similar to many of the banned organochlorine pesticides, although seasonal volatilisation fluxes of $\sum$PCB are sometimes higher than 50 ng/m^2/d. HCB gas exchange fluxes are in the 1 to 10 ng/m^2/d range and fluxes of current-use pesticides γ-HCH and the endosulphans are on the order of 1 to 5 ng/m^2/d.

Inputs to the lakes of pesticides and PCBs are dominated by gas exchange and wet deposition. Dry particle concentration measurements ceased after 1995 due to low reported levels, but loading estimates presented here showed that dry particle deposition of dieldrin, *p,p'*-DDD and PCBs may be significant when compared to the other deposition processes. Dieldrin and $\sum$PCB volatilisation rates are greater than gas absorption so the lakes are acting as sources of these substances to the atmosphere.

Inputs of PAHs and metals are larger than those of pesticides and PCBs as expected by their continued emission to the environment. PAH fluxes range from 1 to 1000 ng/m^2/d

depending on species and loading process, and fluxes of trace metals reach values as high as 2000 $ng/m^2/d$. Since metals are non-volatile, they are subject only to wet and dry deposition with the wet fluxes typically being the larger of the two. Available data indicate that PAH volatilisation from the lakes is small compared to the other flux terms, and gas absorption is substantial for phenanthrene and pyrene while the higher molecular weight PAHs are delivered mostly by wet and dry particle deposition.

As part of its quality assurance program, IADN has begun a new set of intercomparison studies between its participating agencies. Until results are available, comparisons of depositional behaviour between lakes and over time have been limited to those situations where data were generated by the same operating agency.

Wet deposition fluxes are generally decreasing in time for the banned OC pesticides while dry deposition and gas exchange fluxes have been variable. The temporal trend in gas exchange is generally toward air-water equilibrium. For PCBs, wet deposition is steady in time while dry deposition was increasing before measurements ceased in 1995. Gas exchange of PCBs is in the direction of volatilisation on all lakes but generally approaching air-water equilibrium.

Wet and dry particle deposition of PAHs show no consistent trends in time. Levels increase from west to east across the basin. Little net gas exchange flux information is presented for PAHs since water concentration data are sparse. Deposition of metals is limited to wet and dry deposition with wet deposition declining in time and dry deposition being variable.

Loading estimates produced by IADN have traditionally been based on the assumption that Master Stations located at remote sites on the lakes are characterizing the regional background deposition. However, strong inputs with more limited geographic influence are also likely to exist near cities and industrial areas. Using the case of Chicago on Lake Michigan as an example, data from 1996 were used to assess the impact of air pollution from an urban centre on deposition to the lakes. The IADN calculation was modified to include a small lake sub-area influenced by the high concentrations measured at Chicago and, though results should be viewed as lower-bound estimates when compared to other studies, deposition from Chicago sources is still estimated to be substantial for certain pesticides and PCBs and for all PAHs. Further work is needed to correctly characterize the lake area affected by urban air pollution and deduce effective ways of incorporating significant urban centres in IADN loading estimates.

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Appendix A: Derivation of Simplified Mass Transfer Coefficients

Starting with the formulations presented in Hornbuckle *et al.* (1994), the water-side mass transfer coefficient for CO_2 can be expressed as

$$k_{w,CO_2} = 0.45 u_{10}^{1.64} \tag{1}$$

where k_{w,CO_2} = water-side mass transfer coefficient of CO_2 (cm/h)
u_{10} = wind speed measured at 10 m above ground level (m/s).

k_{w,CO_2} is related to the mass transfer coefficient for another substance, x, by

$$k_{w,x} = k_{w,CO_2}\left(\frac{Sc_x}{Sc_{CO_2}}\right)^{-0.5} = 0.45 u_{10}^{1.64}\left(\frac{Sc_x}{Sc_{CO_2}}\right)^{-0.5} \tag{2}$$

where $k_{w,x}$ = water-side mass transfer coefficient of substance x (cm/h)
Sc = Schmidt number (-).

Schmidt number is the dimensionless ratio of kinematic viscosity to diffusivity. With windspeeds measured directly, one need only determine the ratio of Schmidt numbers for CO_2 and the substance of concern to arrive at an estimate of the water-side mass transfer coefficient as in Equation (2).

Previous work has sought to determine Schmidt numbers directly (e.g. Hornbuckle *et al.*, 1994) , but an examination of the desired ratio shows that this is an unnecessary operation since the viscosity term relates only to the solvent and is unaffected by the solute under consideration. As a result, viscosities in numerator and denominator of Equation (3) cancel out and make the ratio of Schmidt numbers equivalent to the ratio of diffusivities.

$$\frac{Sc_x}{Sc_{CO_2}} = \frac{(n/D)_x}{(n/D)_{CO_2}} = \left(\frac{D_{CO_2}}{D_x}\right) \tag{3}$$

where n = kinematic viscosity, $[L^2/T]$, e.g. (cm^2/s)
D = diffusivity, $[L^2/T]$, e.g. (cm^2/s)

The Wilke-Chang method (see Reid *et al.*, 1987) can be used to determine diffusivities as

$$D = \frac{7.4x10^{-8}(\phi M_S)^{0.5} T}{\mu V_m^{0.6}} \tag{4}$$

where D = diffusion coefficient of solute x in solvent S (cm^2/s)
Φ = association factor of solvent S (-)
M_S = molecular weight of solvent S (g/mol)
T = temperature (K)

μ = dynamic viscosity of solvent S (cP)
V_m = molar volume of solute at its normal boiling temperature (cm^3/mol).

Since the solvent properties and temperature are the same for the solvent S whether diffusion of substance x or the reference substance CO_2 is being considered, several terms cancel out when calculating the ratio of diffusivities needed to solve Equation (3). That ratio reduces to the ratio of molar volumes of the solutes raised to the power 0.6. With the molar volume of CO_2 being 29.6 cm^3/mol (Reid *et al.*, 1987),

$$\frac{Sc_x}{Sc_{CO_2}} = \frac{D_{CO_2}}{D_x} = \left(\frac{V_{m,x}}{29.6}\right)^{0.6} \tag{5}$$

and then substituting back into (2) leads to the water-side mass transfer coefficient (cm/h)

$$k_{w,x} = k_{w,CO_2}\left(\frac{Sc_x}{Sc_{CO_2}}\right)^{-0.5} = 0.45u_{10}^{1.64}\left(\left(\frac{V_{m,x}}{29.6}\right)^{0.6}\right)^{-0.5} = 0.45u_{10}^{1.64}\left(\frac{V_{m,x}}{29.6}\right)^{-0.3} \tag{6}$$

Similar simplifications can be made for k_a, the air-side mass transfer coefficient.

$$k_{a,H_2O} = 0.2u_{10} + 0.3 \tag{7}$$

where k_a = air-side mass transfer coefficient of water (cm/s) and

$$k_{a,x} = k_{a,H_2O}\left(\frac{D_{a,x}}{D_{a,H_2O}}\right)^{0.61} \tag{8}$$

where $D_{a,x}$ = diffusivity of compound x in air, [L^2/T], e.g. (cm^2/s)
$D_{a,H2O}$ = diffusivity of water in air, [L^2/T], e.g. (cm^2/s)

The diffusivities here are typically calculated by the Fuller *et al.* method (see Reid *et al.*, 1987) for diffusion of solute x in solvent S as

$$D = \frac{0.00143T^{1.75}}{PM_{xS}^{0.5}\left[(\Sigma V_d)_x^{1/3} + (\Sigma V_d)_S^{1/3}\right]^2} \tag{9}$$

where P = pressure (bar)
M_{xS} = inverse weighted average mass of solute x and solvent S
= $2(M_x^{-1}+M_S^{-1})^{-1}$ (g/mol)
(ΣV_d) = sum of atomic diffusion volumes for compound constituents

When taking the ratio necessary to the air-side mass transfer coefficient calculation, many of the terms cancel out so that

$$\frac{D_{a,x}}{D_{a,H_2O}} = \frac{M_{H_2O,air}{}^{0.5}\left[(\Sigma V_d)_{H_2O}{}^{1/3} + (\Sigma V_d)_{air}{}^{1/3}\right]^2}{M_{x,air}{}^{0.5}\left[(\Sigma V_d)_x{}^{1/3} + (\Sigma V_d)_{air}{}^{1/3}\right]^2} \tag{10}$$

and, substituting values from Reid *et al.* (1987),

$(\Sigma V_d)_{air} = 19.7$ and $(\Sigma V_d)_{H20} = 13.1$
$M_{air} = 29$ g/mol and $M_{H20} = 18$ g/mol,

leads to

$$\frac{D_{a,x}}{D_{a,H_2O}} = \frac{(1/M_x + 1/29)^{0.5}(13.1^{1/3} + 19.7^{1/3})^2}{(1/18 + 1/29)^{0.5}((\Sigma V_d)_x{}^{1/3} + 19.7^{1/3})^2} = 85.3\frac{(1/M_x + 1/29)^{0.5}}{((\Sigma V_d)_x{}^{1/3} + 19.7^{1/3})^2} \tag{11}$$

which requires knowledge only of the molecular mass and sum of molecular diffusion volumes for the compound of interest in order to estimate its diffusivity in air relative to that of water.

The air-side mass transfer coefficient, expressed in cm/s, then reduces to

$$k_{a,x} = k_{a,H_2O}\left(\frac{D_{a,x}}{D_{a,H_2O}}\right)^{0.61} = 15(0.2u_{10} + 0.3)\left[\frac{(1/M_x + 1/29)^{0.5}}{((\Sigma V_d)_x{}^{1/3} + 19.7^{1/3})^2}\right]^{0.61} \tag{12}$$

Appendix B: Selected Data Used in Calculating IADN Loadings

Table B1: Summary of Meteorological Data at IADN Master Stations, 1992-1996

Lake	Parameter	1992	1993	1994	1995	1996
Superior	Annual Precipitation (mm)	665	990	665	904	1148
	Average Water Surface Temperature (K)	278.4	278.4	278.4	279.2	277.7
	Average Wind Speed (m/s)	3.02	3.09	2.99	3.20	2.84
Michigan	Annual Precipitation (mm)	866	1214	866	1182	1200
	Average Water Surface Temperature (K)	280.0	280.0	280.0	282.5	280.8
	Average Wind Speed (m/s)	2.88	2.94	2.90	3.04	2.89
Huron	Annual Precipitation (mm)	1110	1110	896	931	908
	Average Water Surface Temperature (K)	280.8	280.8	280.8	281.8	280.4
	Average Wind Speed (m/s)	2.85	3.50	3.38	3.69	3.36
Erie	Annual Precipitation (mm)	1073	1389	1073	933	823
	Average Water Surface Temperature (K)	283.6	283.6	283.6	284.2	283.4
	Average Wind Speed (m/s)	2.85	2.77	2.63	2.99	2.78
Ontario	Annual Precipitation (mm)	1021	1021	837	816	1000
	Average Water Surface Temperature (K)	281.8	281.8	281.1	282.9	281.7
	Average Wind Speed (m/s)	4.78	4.98	4.66	4.71	4.51

Table B2: Lake Water Concentrations for IADN Loadings Estimates of 1995-96

Substance	Lake Superior				Lake Michigan				Lake Huron				Lake Erie				Lake Ontario			
	Conc. (ng/L)	n	COV (%)	*Source*	Conc. (ng/L)	n	COV (%)	*Source*	Conc. (ng/L)	n	COV (%)	*Source*	Conc. (ng/L)	n	COV (%)	*Source*	Conc. (ng/L)	n	COV (%)	*Source*
α-HCH	1.8988	67	17	*1,2,3,4,5*	0.2342	3	9	*1*	0.5519	3	20	*1*	0.5397	30	33	*1,6*	0.4660	27	25	*1,7*
dieldrin	0.1184	64	14	*1,2,3,4,5*	-	-	-	-	-	-	-	-	0.1531	26	32	*1,6*	0.2416	24	27	*1,7*
cis-chlordane	0.0070	64	43	*2,3,4,5*	0.0059	3	22	*1*	0.0033	3	18	*1*	0.0046	3	25	*1*	0.0054	3	4	*1*
trans-chlordane	0.0042	37	136	*2,3*	0.0037	3	18	*1*	0.0023	3	19	*1*	0.0033	3	21	*1*	0.0049	3	8	*1*
p,p'-DDD	0.0079	37	21	*2,3*	-	-	-	-	-	-	-	-	-	-	-		-	-	-	
p,p'-DDE	0.0060	37	57	*2,3*	-	-	-	-	-	-	-	-	-	-	-		-	-	-	
p,p'-DDT	0.0100	37	176	*2,3*	-	-	-	-	-	-	-	-	-	-	-		-	-	-	
γ-HCH	0.3277	67	30	*1,2,3,4,5*	0.0686	3	6	*1*	0.1158	3	22	*1*	0.1747	30	94	*1,6*	0.1658	27	41	*1,7*
α-endosulphan	0.0138	64	104	*1,2,3,4,5*	-	-	-	-	-	-	-	-	0.1300	21	92	*1,6*	0.0260	24	65	*1,7*
β-endosulphan	0.0038	64	187	*1,2,3,4,5*	-	-	-	-	-	-	-	-	0.0700	8	86	*1,6*	0.0400	24	100	*1,7*
HCB	0.0071	66	172	*1,2,3,4,5*	0.0074	3	16	*1*	0.0095	3	22	*1*	0.0107	18	277	*1,6*	0.0140	26	81	*1,7*
PCB18	0.0025	3	13	*1*	0.0058	3	25	*1*	0.0039	3	15	*1*	0.0120	3	41	*1*	0.0072	3	9	*1*
PCB44	0.0038	3	33	*1*	0.0063	3	13	*1*	0.0030	3	8	*1*	0.0101	3	31	*1*	0.0076	3	4	*1*
PCB52	0.0048	3	30	*1*	0.0011	3	147	*1*	0.0019	3	12	*1*	0.0093	3	69	*1*	0.0057	3	24	*1*
PCB101	0.0027	3	42	*1*	0.0034	3	13	*1*	0.0017	3	5	*1*	0.0052	3	82	*1*	0.0032	3	19	*1*
Σ-PCB	0.0705	3	24	*1*	0.0969	3	3	*1*	0.0500	3	9	*1*	0.1662	3	64	*1*	0.0979	3	11	*1*
phenanthrene	0.5481	27	52	*4,5*	-	-	-	-	-	-	-	-	4.6821	27	95	*6*	1.4180	24	64	*7*
pyrene	0.1298	27	110	*4,5*	-	-	-	-	-	-	-	-	1.2482	25	72	*6*	0.5584	24	69	*7*
B(b+k)F	0.0863	27	40	*4,5*	-	-	-	-	-	-	-	-	0.6433	18	161	*6*	0.3031	24	84	*7*
B(a)P	0.0355	27	70	*4,5*	-	-	-	-	-	-	-	-	0.2660	21	105	*6*	0.1758	24	30	*7*
I(1,2,3-cd)P	0.0467	27	100	*4,5*	-	-	-	-	-	-	-	-	0.4555	13	231	*6*	-	-	-	-
Σ-PAH (UN ECE)	0.1684	-	-	*4,5*	-	-	-	-	-	-	-	-	1.3648	-	-	*6*	-	-	-	-

Data Sources:
1 US R/V Lake Guardian cruise of 1996 analysed by US EPA GLNPO; *2* CCGV Limnos cruise of spring 1996 analysed by EC NWRI; *3* CCGV Limnos cruise of summer 1996 analysed by EC NWRI; *4* CCGV Limnos cruise of spring 1996 analysed by EC EHD; *5* CCGV Limnos cruise of summer 1996 analysed by EC EHD; *6* CCGV Limnos cruise of 1995 analysed by EC EHD; *7* CCGV Limnos cruise of 1998 analysed by EC EHD.

N.B. Multiple source measurements have been pooled with adjustment for sample sizes and precisions. (Taylor, 1990)

Appendix C: IADN Mass Loadings for 1995 and 1996

Table C1: Atmospheric Fluxes to Lake Superior for 1995

(a) Banned Organochlorine Pesticides

Species	Season	Lake Superior 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
a-HCH	W	1.5	120	0.54	100	29	59	-30	53	-0.28	3800
	Sp	0.12	210	0.015	110	26	64	-23	53	2.7	410
	Su	0.6	100	0.0085	100	30	77	-46	53	-16	130
	F	1.6	100	0.064	140	32	79	-49	53	-17	140
	Annual	0.94	140	0.16	200	29	72	-37	53	-7.5	290
dieldrin	W	0.34	54	0.3	140	0.33	190	-8.6	52	-8.3	52
	Sp	0.76	18	0.77	100	1.5	140	-6.6	52	-5.1	67
	Su	0.53	55	0.66	110	4.4	91	-11	52	-6.6	75
	F	2.9	54	0.33	100	1.3	100	-13	52	-12	53
	Annual	1.1	68	0.51	110	1.9	150	-9.8	52	-7.9	70
cis-chlordane	W	0.21	160	0.083	100	0.74	130	-0.81	66	-0.077	1200
	Sp	0.015	100	0.056	100	0.51	81	-0.62	66	-0.11	390
	Su	0.031	54	0.021	120	0.83	88	-0.89	66	-0.054	1300
	F	0.066	100	0.025	130	0.39	83	-1.1	66	-0.74	90
	Annual	0.079	270	0.046	120	0.62	110	-0.86	66	-0.24	390
trans-chlordane	W	0.1	150	0.061	160	2.5	160	-0.61	140	1.9	210
	Sp	0.16	120	0.04	100	0.3	96	-0.47	140	-0.17	410
	Su	0.061	180	0.026	110	0.54	100	-0.6	140	-0.063	1500
	F	0.31	170	0.024	110	0.22	65	-0.8	140	-0.58	200
	Annual	0.16	120	0.038	130	0.9	170	-0.62	140	0.27	3300
trans-nonachlor	W	0.016	32	0.046	150	0.13	190	-0.41	140	-0.27	220
	Sp	0.017	240	0.017	120	0.1	100	-0.31	140	-0.21	210
	Su	0.011	100	0.02	110	0.21	92	-0.32	140	-0.12	400
	F	0.099	-	0.016	110	0.064	81	-0.46	140	-0.4	160
	Annual	0.036	390	0.022	130	0.13	140	-0.38	140	-0.25	250
p,p'-DDD	W	0.05	150	0.0092	100	0.057	93	-0.082	54	-0.025	200
	Sp	0.025	130	0.032	140	0.13	120	-0.063	54	0.069	210
	Su	0.016	140	0.016	120	0.25	110	-0.14	54	0.11	230
	F	0.027	150	0.01	100	0.14	140	-0.15	54	-0.0067	2800
	Annual	0.03	150	0.017	140	0.14	130	-0.11	54	0.037	310
p,p'-DDE	W	0.2	130	0.063	100	0.16	69	-0.77	76	-0.61	88
	Sp	0.07	74	0.022	100	0.21	100	-0.59	76	-0.38	110
	Su	0.042	59	0.029	100	0.4	92	-0.82	76	-0.42	140
	F	0.31	96	0.013	120	0.33	93	-1.1	76	-0.73	100
	Annual	0.15	150	0.032	120	0.27	110	-0.81	76	-0.54	130
p,p'-DDT	W	0.027	26	0.02	100	0.32	120	-0.26	180	0.063	920
	Sp	0.055	230	0.036	140	0.67	140	-0.2	180	0.47	210
	Su	0.052	120	0.24	150	0.45	100	-0.41	180	0.042	2000
	F	0.093	71	0.022	100	0.17	110	-0.45	180	-0.28	290
	Annual	0.057	150	0.079	210	0.4	140	-0.33	180	0.074	820

(b) Current-use Pesticides

Species	Season	Lake Superior 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
g-HCH (lindane)	W	0.31	110	0.093	100	2.2	64	-2.9	58	-0.7	180
	Sp	0.044	35	0.057	110	8.6	75	-2.3	58	6.3	92
	Su	0.58	160	0.031	130	7.8	75	-4.2	58	3.6	140
	F	0.34	130	0.066	130	4	80	-4.5	58	-0.51	560
	Annual	0.32	180	0.062	120	5.6	97	-3.5	58	2.2	250
a-endosulphan	W	3.4	140	0.53	150	0.22	120	-0.0035	120	0.21	120
	Sp	0.028	63	0.82	100	1.6	130	-0.003	120	1.6	130
	Su	0.6	150	1.4	110	31	110	-0.0035	120	31	110
	F	1	150	0.56	120	3.3	120	-0.004	120	3.3	120
	Annual	1.3	270	0.83	120	9.1	220	-0.0035	120	9.1	220
b-endosulphan	W	0.41	78	0.009	100	0.058	100	-3.3E-05	190	0.058	100
	Sp	2.3	87	0.075	150	0.16	120	-2.5E-05	190	0.16	120
	Su	1.4	140	0.57	140	1.8	96	-5.9E-05	190	1.8	97
	F	0.072	110	0.096	170	0.26	200	-6.1E-05	190	0.26	200
	Annual	1	110	0.19	200	0.57	190	-4.5E-05	190	0.57	190
endosulphan sulphate	W	1.7	11	-	-	-	-	-	-	-	-
	Sp	0.65	60	-	-	-	-	-	-	-	-
	Su	0.64	58	-	-	-	-	-	-	-	-
	F	0.11	-	-	-	-	-	-	-	-	-
	Annual	0.79	84	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Superior 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
HCB	W	0.044	42	0.024	110	3.7	59	-2.2	180	1.5	260
	Sp	0.042	56	0.014	110	3.6	63	-1.7	180	1.9	180
	Su	0.021	40	0.011	100	1.9	60	-1.6	180	0.28	1000
	F	0.09	41	0.0067	110	1.8	70	-2.3	180	-0.49	840
	Annual	0.049	68	0.014	120	2.7	64	-1.9	180	0.8	490
PCB18	W	0.045	12	0.061	100	0.16	76	-0.7	52	-0.54	55
	Sp	0.04	90	0.066	100	0.2	74	-0.54	52	-0.35	62
	Su	0.039	47	0.088	110	0.17	73	-0.52	52	-0.35	59
	F	0.14	27	0.034	100	0.14	94	-0.76	52	-0.62	55
	Annual	0.066	140	0.062	110	0.17	85	-0.63	52	-0.46	60
PCB44	W	0.053	35	0.036	110	0.21	79	-0.89	60	-0.68	69
	Sp	0.055	110	0.084	110	0.79	100	-0.69	60	0.1	710
	Su	0.039	55	0.058	100	0.64	98	-0.71	60	-0.066	900
	F	0.15	45	0.055	130	0.53	100	-1	60	-0.47	130
	Annual	0.075	130	0.058	110	0.54	110	-0.82	60	-0.28	430
PCB52	W	0.016	110	0.072	110	0.36	90	-1	58	-0.66	79
	Sp	0.068	60	0.11	100	0.82	83	-0.8	58	0.025	2400
	Su	0.037	130	0.089	100	0.77	96	-0.86	58	-0.09	760
	F	0.23	120	0.05	100	0.59	94	-1.2	58	-0.6	110
	Annual	0.087	320	0.08	110	0.63	110	-0.97	58	-0.33	350
PCB101	W	0.081	14	0.054	100	0.19	88	-0.52	65	-0.33	92
	Sp	0.083	160	0.052	100	0.76	97	-0.4	65	0.35	190
	Su	0.047	27	0.049	100	0.6	89	-0.46	65	0.14	360
	F	0.2	19	0.032	100	0.36	94	-0.64	65	-0.28	150
	Annual	0.1	140	0.047	100	0.48	110	-0.51	65	-0.031	790
Sum-PCB	W	2.2	54	1.6	100	6.6	88	-24	55	-18	65
	Sp	1.7	150	2	100	16	82	-19	55	-2.9	390
	Su	1	36	1.8	100	12	88	-16	55	-3.9	250
	F	4.4	44	0.93	100	8.9	94	-24	55	-15	78
	Annual	2.3	140	1.6	110	11	97	-21	55	-9.9	67

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Superior 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	6.7	95	3.3	100	87	91	-56	72	31	240
	Sp	3.6	43	1.3	100	95	110	-44	72	50	190
	Su	3.5	36	1.7	100	140	70	-61	72	82	110
	F	53	65	1.5	120	670	230	-75	72	590	250
	Annual	17	190	2	110	250	280	-59	72	190	360
PYR	W	5.4	100	2.4	110	3.9	130	-5.4	120	-1.5	510
	Sp	2.3	61	1.2	130	3.3	95	-4.3	120	-1	530
	Su	1.7	35	2.2	110	98	240	-6.6	120	91	260
	F	51	67	1.4	140	260	250	-7.5	120	250	250
	Annual	15	230	1.8	120	91	350	-6	120	85	370
B(b+k)F	W	9.4	54	8.1	110	4	61	-0.14	64	3.9	62
	Sp	5.6	45	1.7	72	4.2	64	-0.11	64	4.1	65
	Su	2.8	33	4.6	81	3.5	58	-0.24	64	3.3	60
	F	67	-	6.8	140	15	150	-0.25	64	15	160
	Annual	21	150	5.3	120	6.7	160	-0.18	64	6.5	170
B(a)P	W	2.1	86	0.38	100	4.2	150	-0.15	86	4.1	160
	Sp	1.8	79	0.56	100	1.6	66	-0.11	86	1.5	69
	Su	0.78	54	0.81	100	1.3	58	-0.26	86	1	65
	F	18	71	0.47	100	3.8	160	-0.27	86	3.5	170
	Annual	5.6	170	0.55	110	2.7	150	-0.2	86	2.5	160
I(1,2,3-cd)P	W	5.3	110	1.4	150	0.97	58	-2.5E-05	110	0.97	58
	Sp	2.4	14	0.73	100	0.98	66	-1.9E-05	110	0.98	66
	Su	0.97	61	1.6	110	0.8	58	-4.4E-05	110	0.8	58
	F	31	-	1.3	150	0.98	59	-4.5E-05	110	0.98	59
	Annual	9.9	190	1.3	130	0.93	61	-3.3E-05	110	0.93	61
sum-PAH (UN ECE)	W	17	48	10	110	9.2	76	-0.29	54	8.9	78
	Sp	9.7	31	3	100	6.7	44	-0.22	54	6.5	44
	Su	4.6	28	7	100	5.6	40	-0.5	54	5.1	42
	F	120	-	8.7	140	20	120	-0.52	54	19	120
	Annual	37	100	7.2	120	10	110	-0.38	54	10	120
Pb	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
As	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Se	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Cd	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

Table C2: Atmospheric Fluxes to Lake Superior for 1996

(a) Banned Organochlorine Pesticides

Species	Season	Lake Superior 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	3.2	63	-	-	20	76	-27	53	-7.1	180
	Sp	2.3	69	-	-	21	62	-20	53	1.8	490
	Su	2.1	68	-	-	25	61	-30	53	-4.8	220
	F	1.8	91	-	-	21	67	-43	53	-22	75
	Annual	2.4	78	-	-	22	68	-30	53	-8	240
dieldrin	W	0.71	170	-	-	0.21	170	-7.9	52	-7.6	52
	Sp	0.58	57	-	-	0.29	110	-5.6	52	-5.3	52
	Su	0.63	42	-	-	3.2	120	-7.4	52	-4.3	99
	F	0.74	39	-	-	2.2	92	-11	52	-9.3	56
	Annual	0.66	69	-	-	1.5	130	-8.1	52	-6.6	58
cis-chlordane	W	0.082	330	-	-	0.19	130	-0.75	66	-0.56	86
	Sp	0.0099	81	-	-	0.25	92	-0.53	66	-0.28	120
	Su	0.062	110	-	-	0.61	94	-0.62	66	-0.01	5400
	F	0.19	90	-	-	0.6	76	-0.98	66	-0.38	150
	Annual	0.087	190	-	-	0.41	90	-0.72	66	-0.31	180
trans-chlordane	W	0.072	410	-	-	0.31	160	-0.57	140	-0.26	350
	Sp	0.036	110	-	-	0.15	100	-0.4	140	-0.24	230
	Su	0.37	190	-	-	0.28	97	-0.43	140	-0.16	410
	F	0.87	75	-	-	0.36	69	-0.69	140	-0.33	290
	Annual	0.34	180	-	-	0.27	96	-0.52	140	-0.25	270
trans-nonachlor	W	0.087	430	-	-	0.05	140	-0.38	140	-0.33	160
	Sp	0.018	57	-	-	0.067	110	-0.26	140	-0.2	190
	Su	0.037	81	-	-	0.16	120	-0.24	140	-0.083	430
	F	0.037	48	-	-	0.13	84	-0.39	140	-0.27	200
	Annual	0.045	180	-	-	0.1	96	-0.32	140	-0.22	190
p,p'-DDD	W	0.026	320	-	-	0.19	150	-0.074	54	0.12	230
	Sp	0.0059	35	-	-	0.031	58	-0.053	54	-0.022	84
	Su	0.011	68	-	-	0.26	120	-0.088	54	0.17	180
	F	0.065	120	-	-	0.43	170	-0.13	54	0.3	240
	Annual	0.027	240	-	-	0.23	180	-0.086	54	0.14	250
p,p'-DDE	W	0.15	46	-	-	0.089	140	-0.71	76	-0.62	84
	Sp	0.036	90	-	-	0.13	100	-0.5	76	-0.37	97
	Su	0.04	21	-	-	0.27	75	-0.58	76	-0.31	130
	F	0.052	22	-	-	0.29	72	-0.91	76	-0.62	100
	Annual	0.069	82	-	-	0.19	110	-0.68	76	-0.48	92
p,p'-DDT	W	0.1	280	-	-	0.069	62	-0.24	180	-0.17	250
	Sp	0.087	150	-	-	0.2	180	-0.17	180	0.031	1400
	Su	0.21	130	-	-	1.5	110	-0.26	180	1.2	140
	F	0.032	120	-	-	0.35	80	-0.39	180	-0.038	1900
	Annual	0.11	130	-	-	0.52	150	-0.26	180	0.26	480

(b) Current-use Pesticides

Species	Season	Lake Superior 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
g-HCH (lindane)	W	1	65	-	-	1.5	100	-2.7	58	-1.1	150
	Sp	1.6	180	-	-	3.6	71	-2	58	1.6	130
	Su	2.1	68	-	-	8.7	89	-2.9	58	5.9	120
	F	0.3	130	-	-	3.4	64	-4.1	58	-0.62	300
	Annual	1.3	140	-	-	4.3	98	-2.9	58	1.4	500
a-endosulphan	W	0.41	250	-	-	0.42	170	-0.0034	120	0.41	180
	Sp	0.65	93	-	-	0.49	97	-0.0028	120	0.48	97
	Su	2.9	72	-	-	16	140	-0.0029	120	16	140
	F	0.44	93	-	-	5.2	150	-0.0037	120	5.2	150
	Annual	1.1	87	-	-	5.5	190	-0.0032	120	5.5	190
b-endosulphan	W	0.077	250	-	-	0.034	70	-0.00003	190	0.034	70
	Sp	0.69	100	-	-	0.046	92	-2.1E-05	190	0.046	92
	Su	5	110	-	-	1.1	150	-3.7E-05	190	1.1	150
	F	0.84	19	-	-	0.4	170	-5.3E-05	190	0.4	170
	Annual	1.6	120	-	-	0.39	170	-3.5E-05	190	0.39	170
endosulphan sulphate	W	0.12	300	-	-	-	-	-	-	-	-
	Sp	0.34	81	-	-	-	-	-	-	-	-
	Su	1.9	81	-	-	-	-	-	-	-	-
	F	0.067	100	-	-	-	-	-	-	-	-
	Annual	0.6	100	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Superior 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
HCB	W	0.046	260	-	-	2.8	69	-2.1	180	0.66	580
	Sp	0.026	63	-	-	2.6	61	-1.4	180	1.1	240
	Su	0.044	35	-	-	1.9	61	-1.2	180	0.75	290
	F	0.045	40	-	-	2.4	59	-2	180	0.45	770
	Annual	0.04	57	-	-	2.4	63	-1.7	180	0.74	280
PCB18	W	0.1	340	-	-	0.096	78	-0.67	52	-0.57	53
	Sp	0.024	35	-	-	0.072	72	-0.46	52	-0.39	53
	Su	0.11	130	-	-	0.096	68	-0.4	52	-0.3	55
	F	0.22	63	-	-	3.8	79	-0.65	52	3.2	89
	Annual	0.11	130	-	-	1	97	-0.54	52	0.47	61
PCB44	W	0.087	410	-	-	0.17	120	-0.84	60	-0.67	70
	Sp	0.016	63	-	-	0.12	100	-0.59	60	-0.47	69
	Su	0.048	93	-	-	0.11	85	-0.53	60	-0.42	68
	F	0.099	44	-	-	9.2	93	-0.86	60	8.3	100
	Annual	0.063	150	-	-	2.4	110	-0.7	60	1.7	73
PCB52	W	0.17	510	-	-	0.2	81	-0.96	58	-0.77	65
	Sp	0.032	76	-	-	0.21	78	-0.68	58	-0.46	72
	Su	0.051	86	-	-	0.21	76	-0.64	58	-0.42	74
	F	0.085	89	-	-	7.3	76	-1	58	6.2	83
	Annual	0.086	200	-	-	2	90	-0.83	58	1.1	79
PCB101	W	0.17	270	-	-	0.15	90	-0.49	65	-0.34	85
	Sp	0.032	45	-	-	0.18	86	-0.34	65	-0.16	130
	Su	0.059	82	-	-	0.21	83	-0.34	65	-0.13	160
	F	0.089	35	-	-	4.1	80	-0.55	65	3.5	89
	Annual	0.087	110	-	-	1.2	100	-0.43	65	0.72	130
Sum-PCB	W	4.4	240	-	-	4.3	82	-23	55	-19	60
	Sp	0.68	46	-	-	6	75	-16	55	-9.8	72
	Su	2.3	110	-	-	4.3	110	-12	55	-7.9	80
	F	4.7	31	-	-	6.1	72	-20	55	-14	64
	Annual	3	110	-	-	5.2	94	-18	55	-13	70

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Superior 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	14	260	7.2	140	150	90	-52	72	94	130
	Sp	2.7	52	2.8	130	55	80	-38	72	17	240
	Su	3.2	44	1.2	100	140	89	-44	72	96	120
	F	6.2	120	2.8	130	150	80	-66	72	82	130
	Annual	6.4	180	3.5	140	120	100	-50	72	72	160
PYR	W	7.2	210	3.8	120	6.6	120	-5	120	1.5	580
	Sp	2.2	59	3.3	130	5	99	-3.8	120	1.2	500
	Su	2.9	88	1.1	110	18	92	-4.7	120	13	120
	F	3.5	120	3.9	140	19	72	-6.7	120	12	110
	Annual	3.9	140	3	140	12	110	-5.1	120	7.1	180
B(b+k)F	W	13	160	5.5	93	4.1	58	-0.12	64	4	59
	Sp	3.5	57	4.5	93	3.5	58	-0.089	64	3.4	59
	Su	4.4	44	2.1	73	2.9	62	-0.15	64	2.7	63
	F	7.9	69	7.8	100	3.2	65	-0.22	64	3	67
	Annual	7.3	140	5	100	3.4	61	-0.15	64	3.3	62
B(a)P	W	1.7	180	0.73	110	1.5	58	-0.13	86	1.4	60
	Sp	1.1	68	1.2	130	1.3	58	-0.096	86	1.2	60
	Su	1.5	53	0.57	110	1	65	-0.16	86	0.88	71
	F	2.2	82	2.1	130	1.4	58	-0.24	86	1.2	63
	Annual	1.6	87	1.2	140	1.3	60	-0.16	86	1.1	63
I(1,2,3-cd)P	W	5.6	220	2.3	110	0.93	58	-2.2E-05	110	0.93	58
	Sp	1.7	67	2.6	140	0.78	58	-1.6E-05	110	0.78	58
	Su	2.5	66	1.1	100	0.64	70	-2.7E-05	110	0.64	70
	F	3.7	93	4.6	130	0.88	58	-0.00004	110	0.88	58
	Annual	3.4	160	2.6	140	0.81	61	-2.6E-05	110	0.81	61
sum-PAH (UN ECE)	W	21	120	8.6	100	6.5	40	-0.26	54	6.3	41
	Sp	6.4	39	8.3	110	5.5	40	-0.19	54	5.3	40
	Su	8.3	33	3.8	100	4.6	43	-0.31	54	4.2	44
	F	14	49	15	110	5.5	42	-0.46	54	5	44
	Annual	12	88	8.8	110	5.5	41	-0.3	54	5.2	42
Pb	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
As	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Se	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Cd	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

Table C3: Atmospheric Fluxes to Lake Michigan for 1995

(a) Banned Organochlorine Pesticides

Species	Season	Lake Michigan 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	2	130	0.29	150	28	61	-3.6	51	24	64
	Sp	1.6	270	0.068	190	28	65	-3.2	51	25	68
	Su	0.33	250	0.46	200	13	88	-8.5	51	4.7	210
	F	6.6	52	0.042	140	20	70	-7.6	51	13	93
	Annual	2.6	210	0.21	210	22	69	-5.7	51	17	81
dieldrin	W	1.2	21	1.3	110	0.3	130	-	-	-	-
	Sp	3	21	1.2	110	11	180	-	-	-	-
	Su	1.9	77	0.65	130	3	140	-	-	-	-
	F	2.8	62	0.71	110	1.7	120	-	-	-	-
	Annual	2.2	110	0.97	110	4	220	-	-	-	-
cis-chlordane	W	0.38	27	0.25	120	0.54	78	-0.65	55	-0.11	330
	Sp	0.42	290	0.069	100	1.4	130	-0.58	55	0.83	200
	Su	0.12	110	0.091	140	0.47	110	-0.71	55	-0.24	220
	F	0.55	27	0.058	160	0.54	90	-1	55	-0.49	110
	Annual	0.37	300	0.12	130	0.74	130	-0.74	55	-0.0051	3600
trans-chlordane	W	0.99	140	0.15	100	0.31	130	-0.51	53	-0.21	190
	Sp	0.27	50	0.053	110	0.96	140	-0.46	53	0.51	260
	Su	0.29	89	0.012	110	0.3	110	-0.48	53	-0.18	190
	F	0.12	73	0.034	160	0.34	99	-0.75	53	-0.41	92
	Annual	0.42	120	0.061	140	0.48	130	-0.55	53	-0.072	1600
trans-nonachlor	W	0.034	12	0.07	100	0.078	100	-0.9	68	-0.82	72
	Sp	0.042	30	0.029	120	0.35	140	-0.8	68	-0.45	140
	Su	0.025	100	0.05	120	0.087	120	-0.62	68	-0.53	76
	F	0.068	60	0.022	120	0.099	83	-1.1	68	-0.99	72
	Annual	0.042	71	0.046	120	0.15	58	-0.85	68	-0.7	110
p,p'-DDD	W	0.086	45	0.026	140	0.072	120	-	-	-	-
	Sp	0.023	110	0.043	140	0.096	93	-	-	-	-
	Su	0.12	280	0.21	130	0.087	81	-	-	-	-
	F	0.072	40	0.074	120	0.093	110	-	-	-	-
	Annual	0.074	220	0.089	160	0.087	160	-	-	-	-
p,p'-DDE	W	0.18	28	0.079	110	0.3	86	-	-	-	-
	Sp	0.76	75	0.075	110	1.3	120	-	-	-	-
	Su	0.11	59	0.067	150	0.67	74	-	-	-	-
	F	0.36	49	0.039	100	0.71	87	-	-	-	-
	Annual	0.35	140	0.065	120	0.74	120	-	-	-	-
p,p'-DDT	W	0.19	110	0.029	100	0.56	100	-	-	-	-
	Sp	0.77	120	0.019	100	0.74	100	-	-	-	-
	Su	0.16	180	0.028	100	0.54	100	-	-	-	-
	F	0.72	78	0.051	130	0.28	85	-	-	-	-
	Annual	0.46	150	0.032	130	0.53	120	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Michigan 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %
g-HCH (lindane)	W	0.43	120	0.062	110	2.2	65	-0.6	50	1.6	76
	Sp	1.2	120	0.2	120	19	140	-0.54	50	18	150
	Su	0.81	310	0.11	140	15	88	-1.3	50	14	93
	F	2.5	20	0.045	130	3.9	72	-1.2	50	2.7	90
	Annual	1.2	130	0.1	130	9.9	160	-0.9	50	9	170
a-endosulphan	W	0.84	18	1.1	100	0.27	96	-	-	-	-
	Sp	0.59	87	1.6	110	23	190	-	-	-	-
	Su	0.7	230	1.2	130	74	130	-	-	-	-
	F	1	53	0.83	150	3.5	120	-	-	-	-
	Annual	0.8	130	1.2	120	25	240	-	-	-	-
b-endosulphan	W	0.35	66	0.046	140	0.11	91	-	-	-	-
	Sp	1	96	1.5	160	1.2	170	-	-	-	-
	Su	0.9	250	2.9	190	4.3	130	-	-	-	-
	F	1.4	30	0.26	130	0.21	120	-	-	-	-
	Annual	0.91	120	1.2	230	1.5	230	-	-	-	-
endosulphan sulphate	W	4.6	59	-	-	-	-	-	-	-	-
	Sp	0.69	81	-	-	-	-	-	-	-	-
	Su	0.76	140	-	-	-	-	-	-	-	-
	F	0.72	65	-	-	-	-	-	-	-	-
	Annual	1.7	97	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Michigan 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %
HCB	W	0.064	27	0.0097	140	3.4	59	-2.1	53	1.3	99
	Sp	0.072	22	0.018	110	3.7	65	-1.9	53	1.9	97
	Su	0.049	35	0.03	150	0.69	76	-1.3	53	-0.58	92
	F	0.076	44	0.009	120	1.2	65	-2.3	53	-1.1	78
	Annual	0.065	72	0.017	140	2.3	72	-1.9	53	0.39	1500
PCB18	W	0.13	19	0.082	100	0.16	68	-1.5	56	-1.3	58
	Sp	0.11	46	0.041	100	0.33	110	-1.3	56	-0.97	70
	Su	0.16	45	0.049	110	0.072	69	-0.93	56	-0.86	57
	F	0.088	92	0.042	100	0.2	96	-1.7	56	-1.5	59
	Annual	0.12	100	0.053	110	0.19	100	-1.3	56	-1.2	59
PCB44	W	0.12	23	0.088	150	0.16	100	-1.4	52	-1.2	53
	Sp	0.084	68	0.018	130	0.64	84	-1.2	52	-0.58	94
	Su	0.066	76	0.03	100	0.26	150	-0.96	52	-0.7	76
	F	0.076	49	0.065	140	0.42	150	-1.7	52	-1.2	71
	Annual	0.086	130	0.05	150	0.37	140	-1.3	52	-0.93	70
PCB52	W	0.22	13	0.13	130	0.27	66	-0.22	150	0.047	740
	Sp	0.12	55	0.08	100	0.56	100	-0.2	150	0.37	170
	Su	0.11	47	0.11	120	0.16	67	-0.17	150	-0.0047	5400
	F	0.12	64	0.061	100	0.43	98	-0.28	150	0.16	350
	Annual	0.14	180	0.093	120	0.36	98	-0.22	150	0.14	360
PCB101	W	0.14	35	0.2	170	0.15	71	-0.63	52	-0.48	55
	Sp	0.098	42	0.038	100	0.32	110	-0.56	52	-0.23	160
	Su	0.066	70	0.04	110	0.079	63	-0.5	52	-0.42	53
	F	0.088	65	0.025	100	0.2	110	-0.83	52	-0.63	62
	Annual	0.098	120	0.075	210	0.19	100	-0.63	52	-0.44	64
Sum-PCB	W	4.7	18	3.8	140	3.2	87	-22	50	-18	52
	Sp	4.1	27	1.8	110	8.6	110	-19	50	-11	96
	Su	3.6	44	1.2	100	1.8	80	-15	50	-13	51
	F	2.5	80	0.95	100	5	120	-26	50	-21	57
	Annual	3.7	87	1.9	140	4.7	110	-20	50	-16	57

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Michigan 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	22	83	5.6	110	250	70	-	-	-	-
	Sp	14	66	3	110	130	130	-	-	-	-
	Su	7.3	37	3.1	110	70	81	-	-	-	-
	F	25	74	3.8	130	110	80	-	-	-	-
	Annual	17	190	3.9	110	140	93	-	-	-	-
PYR	W	20	98	6.2	100	13	120	-	-	-	-
	Sp	17	32	4.5	120	9.5	190	-	-	-	-
	Su	4.3	99	3.1	100	7.1	95	-	-	-	-
	F	24	57	4.2	120	11	77	-	-	-	-
	Annual	16	150	4.5	110	10	120	-	-	-	-
B(b+k)F	W	32	70	15	84	3.7	59	-	-	-	-
	Sp	24	36	7.7	83	3.3	61	-	-	-	-
	Su	7.8	62	7.3	75	3.6	66	-	-	-	-
	F	27	45	7.7	110	3.6	61	-	-	-	-
	Annual	22	120	9.4	95	3.5	69	-	-	-	-
B(a)P	W	9.1	76	1.9	100	1.4	59	-	-	-	-
	Sp	7	36	2.4	130	1.3	60	-	-	-	-
	Su	2.4	84	1.2	100	1.2	72	-	-	-	-
	F	12	35	1.6	120	1.3	61	-	-	-	-
	Annual	7.7	140	1.8	120	1.3	66	-	-	-	-
I(1,2,3-cd)P	W	16	83	6.7	100	0.85	59	-	-	-	-
	Sp	9.8	55	2.4	110	0.81	60	-	-	-	-
	Su	3.1	110	1.8	110	0.83	72	-	-	-	-
	F	19	26	3.6	130	0.87	59	-	-	-	-
	Annual	12	110	3.6	120	0.84	64	-	-	-	-
sum-PAH (UN ECE)	W	58	48	24	100	5.9	40	-	-	-	-
	Sp	41	27	12	100	5.4	41	-	-	-	-
	Su	13	48	10	100	5.6	46	-	-	-	-
	F	58	26	13	110	5.8	41	-	-	-	-
	Annual	42	73	15	110	5.7	47	-	-	-	-
Pb	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
As	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Se	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Cd	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

Table C4: Atmospheric Fluxes to Lake Michigan for 1996

(a) Banned Organochlorine Pesticides

Species	Season	Lake Michigan 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	1.7	120	-	-	23	66	-3.3	51	20	71
	Sp	0.0082	150	-	-	22	61	-2.9	51	19	64
	Su	0.82	180	-	-	18	72	-6.3	51	11	95
	F	0.37	120	-	-	13	68	-6.9	51	5.8	110
	Annual	0.71	260	-	-	19	72	-4.9	51	14	86
dieldrin	W	3.1	87	-	-	0.48	110	-	-	-	-
	Sp	0.41	62	-	-	0.75	160	-	-	-	-
	Su	1.6	38	-	-	3.7	89	-	-	-	-
	F	0.48	180	-	-	2.8	120	-	-	-	-
	Annual	1.4	120	-	-	1.9	150	-	-	-	-
cis-chlordane	W	0.3	97	-	-	0.31	87	-0.64	55	-0.33	94
	Sp	0.0082	120	-	-	0.5	88	-0.56	55	-0.055	710
	Su	0.096	150	-	-	0.65	87	-0.62	55	0.031	1500
	F	0.33	110	-	-	0.63	100	-0.9	55	-0.27	220
	Annual	0.18	190	-	-	0.52	120	-0.68	55	-0.15	2200
trans-chlordane	W	0.18	190	-	-	0.26	180	-0.51	53	-0.25	190
	Sp	0.49	140	-	-	0.31	87	-0.45	53	-0.14	170
	Su	0.95	88	-	-	0.4	89	-0.43	53	-0.034	880
	F	0.19	140	-	-	0.49	110	-0.64	53	-0.15	350
	Annual	0.45	130	-	-	0.36	130	-0.51	53	-0.14	840
trans-nonachlor	W	0.016	31	-	-	0.074	96	-0.96	68	-0.88	71
	Sp	0.03	-	-	-	0.14	74	-0.82	68	-0.69	76
	Su	0.11	130	-	-	0.13	99	-0.57	68	-0.44	82
	F	0.025	58	-	-	0.12	110	-0.92	68	-0.81	74
	Annual	0.045	130	-	-	0.11	120	-0.82	68	-0.7	410
p,p'-DDD	W	0.098	100	-	-	0.46	120	-	-	-	-
	Sp	0.0055	110	-	-	0.035	58	-	-	-	-
	Su	0.1	110	-	-	0.22	110	-	-	-	-
	F	0.13	50	-	-	0.65	130	-	-	-	-
	Annual	0.084	110	-	-	0.34	180	-	-	-	-
p,p'-DDE	W	0.15	100	-	-	0.17	98	-	-	-	-
	Sp	0.13	79	-	-	0.73	120	-	-	-	-
	Su	0.16	58	-	-	0.7	82	-	-	-	-
	F	0.31	32	-	-	0.9	130	-	-	-	-
	Annual	0.19	79	-	-	0.62	130	-	-	-	-
p,p'-DDT	W	0.089	56	-	-	0.11	81	-	-	-	-
	Sp	0.19	190	-	-	0.17	110	-	-	-	-
	Su	0.65	330	-	-	1.5	88	-	-	-	-
	F	0.78	88	-	-	0.71	130	-	-	-	-
	Annual	0.43	220	-	-	0.61	160	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Michigan 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
g-HCH (lindane)	W	0.69	71	-	-	2.2	72	-0.56	50	1.7	86
	Sp	0.03	190	-	-	5.8	88	-0.5	50	5.3	93
	Su	0.5	310	-	-	12	100	-0.98	50	11	110
	F	0.036	110	-	-	3.3	85	-1.1	50	2.2	110
	Annual	0.31	290	-	-	5.9	140	-0.78	50	5.1	160
a-endosulphan	W	0.35	110	-	-	0.84	120	-	-	-	-
	Sp	0.085	150	-	-	1.3	170	-	-	-	-
	Su	1.9	190	-	-	54	110	-	-	-	-
	F	0.28	280	-	-	12	200	-	-	-	-
	Annual	0.65	230	-	-	17	230	-	-	-	-
b-endosulphan	W	0.33	77	-	-	0.068	100	-	-	-	-
	Sp	0.011	230	-	-	0.26	140	-	-	-	-
	Su	1.1	390	-	-	2.7	160	-	-	-	-
	F	0.033	90	-	-	3.9	260	-	-	-	-
	Annual	0.37	460	-	-	1.7	300	-	-	-	-
endosulphan sulphate	W	0.24	70	-	-	-	-	-	-	-	-
	Sp	0.016	-	-	-	-	-	-	-	-	-
	Su	0.89	280	-	-	-	-	-	-	-	-
	F	0.18	270	-	-	-	-	-	-	-	-
	Annual	0.33	300	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Michigan 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
HCB	W	0.058	69	-	-	2.8	71	-2.3	53	0.5	300
	Sp	0.014	61	-	-	3.4	61	-2	53	1.4	100
	Su	0.057	55	-	-	1.4	75	-1.2	53	0.16	490
	F	0.044	35	-	-	1.5	62	-2	53	-0.48	140
	Annual	0.043	48	-	-	2.2	74	-1.9	53	0.39	340
PCB18	W	0.14	100	-	-	0.15	89	-1.6	56	-1.4	58
	Sp	0.016	73	-	-	0.17	79	-1.4	56	-1.2	58
	Su	0.087	46	-	-	0.21	120	-0.87	56	-0.66	69
	F	0.073	15	-	-	0.17	100	-1.4	56	-1.3	59
	Annual	0.08	65	-	-	0.18	150	-1.3	56	-1.1	66
PCB44	W	0.075	160	-	-	0.11	80	-1.5	52	-1.4	52
	Sp	0.014	120	-	-	0.13	100	-1.3	52	-1.1	53
	Su	0.031	72	-	-	0.2	110	-0.89	52	-0.68	60
	F	0.065	46	-	-	0.4	190	-1.4	52	-1	92
	Annual	0.046	75	-	-	0.21	190	-1.3	52	-1	80
PCB52	W	0.19	140	-	-	0.24	80	-0.23	150	0.011	3400
	Sp	0.033	96	-	-	0.31	74	-0.2	150	0.1	330
	Su	0.092	54	-	-	0.39	90	-0.15	150	0.24	160
	F	0.1	24	-	-	0.29	110	-0.24	150	0.058	770
	Annual	0.1	55	-	-	0.31	120	-0.21	150	0.1	280
PCB101	W	0.12	81	-	-	0.11	79	-0.65	52	-0.54	54
	Sp	0.014	81	-	-	0.17	80	-0.56	52	-0.39	60
	Su	0.048	83	-	-	0.2	84	-0.45	52	-0.25	78
	F	0.076	58	-	-	0.16	110	-0.71	52	-0.55	61
	Annual	0.064	93	-	-	0.16	130	-0.59	52	-0.43	89
Sum-PCB	W	3	110	-	-	3	83	-23	50	-20	51
	Sp	0.48	80	-	-	4.2	83	-20	50	-16	53
	Su	3	54	-	-	5.7	100	-14	50	-8	80
	F	2.6	37	-	-	4.6	110	-22	50	-17	57
	Annual	2.3	44	-	-	4.4	140	-20	50	-15	75

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Michigan 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	36	55	10	110	240	87	-	-	-	-
	Sp	1.7	140	5	120	80	76	-	-	-	-
	Su	3.4	230	1.7	110	160	160	-	-	-	-
	F	1.1	92	2.9	110	94	90	-	-	-	-
	Annual	10	340	5	130	140	150	-	-	-	-
PYR	W	23	65	9.7	110	14	100	-	-	-	-
	Sp	1.4	110	6	130	5.7	91	-	-	-	-
	Su	2	150	1.5	110	22	120	-	-	-	-
	F	0.85	130	3.3	130	8.7	100	-	-	-	-
	Annual	6.8	340	5.1	140	12	150	-	-	-	-
B(b+k)F	W	30	47	19	95	6.9	77	-	-	-	-
	Sp	4.4	-	8.9	95	3.9	58	-	-	-	-
	Su	11	31	2.6	73	2.6	61	-	-	-	-
	F	3.7	180	6.5	85	3.1	70	-	-	-	-
	Annual	12	140	9.2	110	4.1	68	-	-	-	-
B(a)P	W	10	84	2.7	130	2	66	-	-	-	-
	Sp	1.5	73	2.5	120	1.7	74	-	-	-	-
	Su	3.4	63	0.65	100	1	61	-	-	-	-
	F	0.82	220	1.9	120	1.5	71	-	-	-	-
	Annual	4	160	1.9	130	1.5	68	-	-	-	-
I(1,2,3-cd)P	W	15	38	7.7	120	0.94	58	-	-	-	-
	Sp	2.5	-	6.4	140	1.3	100	-	-	-	-
	Su	5.8	66	1.4	100	0.65	61	-	-	-	-
	F	1.7	250	3.5	110	0.98	69	-	-	-	-
	Annual	6.3	160	4.8	130	0.96	82	-	-	-	-
sum-PAH (UN ECE)	W	55	33	29	110	9.8	56	-	-	-	-
	Sp	8.4	-	18	110	6.9	42	-	-	-	-
	Su	20	29	4.5	100	4.3	41	-	-	-	-
	F	6.2	130	12	100	5.6	45	-	-	-	-
	Annual	23	89	16	110	6.7	45	-	-	-	-
Pb	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
As	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Se	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Cd	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

Table C5: Atmospheric Fluxes to Lake Huron for 1995

(a) Banned Organochlorine Pesticides

Species	Season	Lake Huron 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	7.8	160	-	-	13	58	-9.9	54	3.1	290
	Sp	11	140	-	-	13	63	-7.9	54	4.7	160
	Su	6.9	120	-	-	12	67	-21	54	-8.6	180
	F	15	88	-	-	12	62	-21	54	-8.4	180
	Annual	10	140	-	-	13	67	-15	54	-2.3	1100
dieldrin	W	0.17	220	-	-	0.87	78	-	-	-	-
	Sp	1.8	88	-	-	0.8	77	-	-	-	-
	Su	0.62	87	-	-	1.9	95	-	-	-	-
	F	0.93	160	-	-	1.9	130	-	-	-	-
	Annual	0.88	200	-	-	1.4	130	-	-	-	-
cis-chlordane	W	-	-	-	-	0.28	-	-0.49	53	-0.21	-
	Sp	-	-	-	-	0.2	64	-0.35	53	-0.15	170
	Su	-	-	-	-	0.28	94	-0.49	53	-0.21	190
	F	-	-	-	-	0.43	120	-0.85	53	-0.42	180
	Annual	-	-	-	-	0.3	120	-0.55	53	-0.25	330
trans-chlordane	W	-	-	-	-	0.24	72	-0.45	54	-0.2	190
	Sp	-	-	-	-	0.16	67	-0.32	54	-0.16	150
	Su	-	-	-	-	0.16	90	-0.38	54	-0.22	130
	F	-	-	-	-	0.26	120	-0.72	54	-0.46	130
	Annual	-	-	-	-	0.21	110	-0.47	54	-0.26	180
trans-nonachlor	W	-	-	-	-	0.098	80	-0.69	52	-0.59	93
	Sp	-	-	-	-	0.093	66	-0.45	52	-0.36	94
	Su	-	-	-	-	0.084	99	-0.39	52	-0.31	97
	F	-	-	-	-	0.14	120	-0.9	52	-0.77	91
	Annual	-	-	-	-	0.1	130	-0.61	52	-0.51	100
p,p'-DDD	W	0.15	310	-	-	0.024	-	-	-	-	-
	Sp	0.17	400	-	-	0.037	100	-	-	-	-
	Su	0.13	60	-	-	0.082	-	-	-	-	-
	F	0.25	550	-	-	0.044	64	-	-	-	-
	Annual	0.18	400	-	-	0.047	87	-	-	-	-
p,p'-DDE	W	0	0	-	-	0	0	-	-	-	-
	Sp	0.76	140	-	-	0.41	61	-	-	-	-
	Su	0.58	220	-	-	0.26	71	-	-	-	-
	F	0.21	410	-	-	0.45	81	-	-	-	-
	Annual	0.44	190	-	-	0.4	78	-	-	-	-
p,p'-DDT	W	0	0	-	-	0	0	-	-	-	-
	Sp	0.21	380	-	-	0.098	68	-	-	-	-
	Su	1.2	240	-	-	0.34	76	-	-	-	-
	F	0.29	550	-	-	0.23	100	-	-	-	-
	Annual	0.47	1200	-	-	0.2	110	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Huron 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %
g-HCH (lindane)	W	0.93	110	-	-	2	58	-1.2	55	0.83	140
	Sp	9.8	68	-	-	3	81	-0.95	55	2	110
	Su	3.1	82	-	-	4.9	82	-2.3	55	2.6	140
	F	5.8	130	-	-	2.6	72	-2.3	55	0.38	540
	Annual	4.9	100	-	-	3.1	98	-1.7	55	1.5	170
a-endosulphan	W	0.27	180	-	-	1.3	59	-	-	-	-
	Sp	5.1	170	-	-	1.5	84	-	-	-	-
	Su	3	65	-	-	12	110	-	-	-	-
	F	0.61	260	-	-	2.8	92	-	-	-	-
	Annual	2.2	170	-	-	4.3	170	-	-	-	-
b-endosulphan	W	1.3	100	-	-	-	-	-	-	-	-
	Sp	4.8	98	-	-	0.14	100	-	-	-	-
	Su	4.6	74	-	-	1.6	130	-	-	-	-
	F	1.7	120	-	-	0.32	120	-	-	-	-
	Annual	3.1	97	-	-	-	-	-	-	-	-
endosulphan sulphate	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Huron 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %
HCB	W	0.13	160	-	-	3.6	59	-4.4	55	-0.72	530
	Sp	0.17	99	-	-	2.3	61	-2.9	55	-0.52	420
	Su	0.3	210	-	-	0.33	64	-2.2	55	-1.9	95
	F	0.05	130	-	-	1.8	61	-5.1	55	-3.3	120
	Annual	0.16	210	-	-	2	66	-3.6	55	-1.6	130
PCB18	W	-	-	-	-	0	0	-1.6	52	-0.66	200
	Sp	-	-	-	-	0.9	59	-1	52	-0.13	540
	Su	-	-	-	-	0.26	61	-0.83	52	-0.57	100
	F	-	-	-	-	0.71	75	-1.9	52	-1.2	120
	Annual	-	-	-	-	0.69	67	-1.3	52	-0.63	140
PCB44	W	-	-	-	-	0.18	63	-1	51	-0.82	89
	Sp	-	-	-	-	0.083	63	-0.67	51	-0.59	78
	Su	-	-	-	-	0.061	71	-0.6	51	-0.53	77
	F	-	-	-	-	0.15	93	-1.3	51	-1.1	78
	Annual	-	-	-	-	0.12	83	-0.89	51	-0.77	79
PCB52	W	-	-	-	-	0	0	-0.56	51	-0.37	120
	Sp	-	-	-	-	0.19	63	-0.39	51	-0.2	130
	Su	-	-	-	-	0.11	68	-0.37	51	-0.26	99
	F	-	-	-	-	0.24	97	-0.76	51	-0.52	110
	Annual	-	-	-	-	0.18	81	-0.52	51	-0.34	110
PCB101	W	-	-	-	-	0	0	-0.45	50	-0.36	89
	Sp	-	-	-	-	0.073	61	-0.31	50	-0.24	81
	Su	-	-	-	-	0.052	76	-0.32	50	-0.26	77
	F	-	-	-	-	0.1	110	-0.65	50	-0.55	78
	Annual	-	-	-	-	0.08	97	-0.43	50	-0.35	82
Sum-PCB	W	-	-	-	-	6.2	65	-17	51	-11	120
	Sp	-	-	-	-	4.8	63	-12	51	-6.9	110
	Su	-	-	-	-	1.8	63	-10	51	-8.3	84
	F	-	-	-	-	4.4	77	-22	51	-17	86
	Annual	-	-	-	-	4.3	68	-15	51	-11	91

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Huron 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	14	79	3.3	120	-	-	-	-	-	-
	Sp	12	140	4.6	130	-	-	-	-	-	-
	Su	3.6	53	1.6	110	-	-	-	-	-	-
	F	15	360	2	110	-	-	-	-	-	-
	Annual	11	380	2.9	130	-	-	-	-	-	-
PYR	W	11	88	2.6	140	-	-	-	-	-	-
	Sp	10	110	4	140	-	-	-	-	-	-
	Su	2.5	79	1.9	120	-	-	-	-	-	-
	F	16	190	2.8	140	-	-	-	-	-	-
	Annual	10	400	2.8	140	-	-	-	-	-	-
B(b+k)F	W	21	220	-	-	-	-	-	-	-	-
	Sp	23	290	-	-	-	-	-	-	-	-
	Su	18	43	-	-	-	-	-	-	-	-
	F	51	300	-	-	-	-	-	-	-	-
	Annual	28	240	-	-	-	-	-	-	-	-
B(a)P	W	13	310	-	-	-	-	-	-	-	-
	Sp	16	380	-	-	-	-	-	-	-	-
	Su	11	60	-	-	-	-	-	-	-	-
	F	23	520	-	-	-	-	-	-	-	-
	Annual	16	380	-	-	-	-	-	-	-	-
I(1,2,3-cd)P	W	27	310	3.8	130	-	-	-	-	-	-
	Sp	33	380	3.1	130	-	-	-	-	-	-
	Su	23	60	3.3	130	-	-	-	-	-	-
	F	44	580	3.6	130	-	-	-	-	-	-
	Annual	32	390	3.5	130	-	-	-	-	-	-
sum-PAH (UN ECE)	W	60	170	-	-	-	-	-	-	-	-
	Sp	73	210	-	-	-	-	-	-	-	-
	Su	53	34	-	-	-	-	-	-	-	-
	F	120	270	-	-	-	-	-	-	-	-
	Annual	76	200	-	-	-	-	-	-	-	-
Pb	W	840	56	590	110	-	-	-	-	-	-
	Sp	730	68	430	160	-	-	-	-	-	-
	Su	290	57	160	160	-	-	-	-	-	-
	F	910	71	210	190	-	-	-	-	-	-
	Annual	690	180	350	150	-	-	-	-	-	-
As	W	140	85	18	170	-	-	-	-	-	-
	Sp	110	61	44	150	-	-	-	-	-	-
	Su	51	54	21	180	-	-	-	-	-	-
	F	97	17	47	200	-	-	-	-	-	-
	Annual	100	210	33	190	-	-	-	-	-	-
Se	W	130	58	-	-	-	-	-	-	-	-
	Sp	130	64	-	-	-	-	-	-	-	-
	Su	58	80	5.5	170	-	-	-	-	-	-
	F	190	34	16	250	-	-	-	-	-	-
	Annual	130	190	5.3	360	-	-	-	-	-	-
Cd	W	90	75	6.2	160	-	-	-	-	-	-
	Sp	50	44	16	170	-	-	-	-	-	-
	Su	41	43	3.5	260	-	-	-	-	-	-
	F	78	14	5.4	200	-	-	-	-	-	-
	Annual	65	180	7.7	210	-	-	-	-	-	-

Table C6: Atmospheric Fluxes to Lake Huron for 1996

(a) Banned Organochlorine Pesticides

Species	Season	Lake Huron 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	13	94	-	-	9.2	68	-9.5	54	-0.25	3500
	Sp	12	190	-	-	12	62	-7.1	54	4.8	140
	Su	2.7	63	-	-	7.9	62	-15	54	-7.6	150
	F	2.5	100	-	-	8.9	61	-18	54	-8.6	150
	Annual	7.4	240	-	-	9.5	66	-12	54	-2.9	360
dieldrin	W	1.2	410	-	-	0.73	110	-	-	-	-
	Sp	1	210	-	-	0.87	100	-	-	-	-
	Su	3.2	140	-	-	1.5	84	-	-	-	-
	F	2.1	72	-	-	1.9	74	-	-	-	-
	Annual	1.9	160	-	-	1.2	100	-	-	-	-
cis-chlordane	W	-	-	-	-	0.14	96	-0.48	53	-0.34	120
	Sp	-	-	-	-	0.26	84	-0.32	53	-0.059	460
	Su	-	-	-	-	0.25	79	-0.42	53	-0.17	190
	F	-	-	-	-	0.36	83	-0.59	53	-0.23	200
	Annual	-	-	-	-	0.25	97	-0.45	53	-0.2	310
trans-chlordane	W	-	-	-	-	0.14	110	-0.44	54	-0.3	130
	Sp	-	-	-	-	0.18	84	-0.29	54	-0.11	220
	Su	-	-	-	-	0.14	97	-0.33	54	-0.19	140
	F	-	-	-	-	0.32	74	-0.49	54	-0.17	230
	Annual	-	-	-	-	0.2	110	-0.39	54	-0.19	200
trans-nonachlor	W	-	-	-	-	0.057	88	-0.71	52	-0.65	86
	Sp	-	-	-	-	0.12	88	-0.42	52	-0.31	100
	Su	-	-	-	-	0.076	81	-0.35	52	-0.28	96
	F	-	-	-	-	0.12	75	-0.56	52	-0.43	96
	Annual	-	-	-	-	0.094	100	-0.51	52	-0.42	100
p,p'-DDD	W	0.29	280	-	-	0.036	70	-	-	-	-
	Sp	0.23	530	-	-	0.039	74	-	-	-	-
	Su	0.22	2500	-	-	0.034	89	-	-	-	-
	F	0.49	260	-	-	0.047	77	-	-	-	-
	Annual	0.31	960	-	-	0.039	84	-	-	-	-
p,p'-DDE	W	0	0	-	-	0	0	-	-	-	-
	Sp	0.14	170	-	-	0.33	89	-	-	-	-
	Su	0.13	2600	-	-	0.17	100	-	-	-	-
	F	0.35	92	-	-	0.33	84	-	-	-	-
	Annual	0.36	1900	-	-	0.29	96	-	-	-	-
p,p'-DDT	W	0	0	-	-	0	0	-	-	-	-
	Sp	0.45	210	-	-	0.15	100	-	-	-	-
	Su	0.26	2500	-	-	0.16	97	-	-	-	-
	F	0.18	36	-	-	0.21	81	-	-	-	-
	Annual	0.82	2500	-	-	0.14	100	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Huron 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
g-HCH (lindane)	W	1.9	94	-	-	1.3	66	-1.1	55	0.18	600
	Sp	8.8	110	-	-	3.2	93	-0.85	55	2.4	120
	Su	3.8	140	-	-	4.4	86	-1.7	55	2.7	130
	F	2.5	63	-	-	2	66	-1.9	55	0.098	1600
	Annual	4.3	160	-	-	2.7	110	-1.4	55	1.3	190
a-endosulphan	W	0.92	94	-	-	0.99	68	-	-	-	-
	Sp	0.92	82	-	-	1.2	96	-	-	-	-
	Su	2.6	220	-	-	5.2	96	-	-	-	-
	F	0.99	68	-	-	3.2	130	-	-	-	-
	Annual	1.4	230	-	-	2.7	140	-	-	-	-
b-endosulphan	W	0.77	130	-	-	0.025	-	-	-	-	-
	Sp	2.4	140	-	-	0.13	96	-	-	-	-
	Su	4.6	110	-	-	0.53	89	-	-	-	-
	F	2.2	60	-	-	0.24	130	-	-	-	-
	Annual	2.5	140	-	-	0.23	120	-	-	-	-
endosulphan sulphate	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Huron 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
HCB	W	0.23	180	-	-	3.3	61	-4.6	55	-1.3	310
	Sp	0.0077	350	-	-	2.5	61	-2.7	55	-0.23	910
	Su	0.0072	2800	-	-	0.49	67	-2	55	-1.5	110
	F	0.0049	51	-	-	0.94	64	-3.2	55	-2.2	110
	Annual	0.062	490	-	-	1.8	65	-3.1	55	-1.3	140
PCB18	W	-	-	-	-	0	0	-1.6	52	-0.77	170
	Sp	-	-	-	-	0.51	77	-0.99	52	-0.47	150
	Su	-	-	-	-	0.14	62	-0.75	52	-0.6	92
	F	-	-	-	-	0.31	97	-1.2	52	-0.88	100
	Annual	-	-	-	-	0.46	77	-1.1	52	-0.68	110
PCB44	W	-	-	-	-	0.11	64	-1	51	-0.92	81
	Sp	-	-	-	-	0.093	74	-0.64	51	-0.54	80
	Su	-	-	-	-	0.046	64	-0.53	51	-0.49	76
	F	-	-	-	-	0.1	90	-0.83	51	-0.73	79
	Annual	-	-	-	-	0.088	86	-0.76	51	-0.67	78
PCB52	W	-	-	-	-	0	0	-0.58	51	-0.39	110
	Sp	-	-	-	-	0.22	77	-0.37	51	-0.15	180
	Su	-	-	-	-	0.11	67	-0.33	51	-0.22	110
	F	-	-	-	-	0.24	76	-0.5	51	-0.26	140
	Annual	-	-	-	-	0.19	82	-0.44	51	-0.25	130
PCB101	W	-	-	-	-	0	0	-0.45	50	-0.38	84
	Sp	-	-	-	-	0.1	78	-0.29	50	-0.19	95
	Su	-	-	-	-	0.057	63	-0.28	50	-0.22	79
	F	-	-	-	-	0.081	70	-0.43	50	-0.34	79
	Annual	-	-	-	-	0.079	80	-0.36	50	-0.28	84
Sum-PCB	W	-	-	-	-	4.1	61	-18	51	-14	96
	Sp	-	-	-	-	2.7	71	-11	51	-8.4	90
	Su	-	-	-	-	1.1	65	-9	51	-7.8	80
	F	-	-	-	-	2.7	90	-14	51	-11	86
	Annual	-	-	-	-	2.6	81	-13	51	-10	86

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Huron 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	31	190	9	110	-	-	-	-	-	-
	Sp	13	160	2.9	120	-	-	-	-	-	-
	Su	14	520	2.8	130	-	-	-	-	-	-
	F	14	77	6.2	130	-	-	-	-	-	-
	Annual	18	290	5.2	130	-	-	-	-	-	-
PYR	W	36	190	7.4	110	-	-	-	-	-	-
	Sp	13	160	4.1	110	-	-	-	-	-	-
	Su	6.3	1100	4.9	120	-	-	-	-	-	-
	F	8.4	90	7.4	130	-	-	-	-	-	-
	Annual	16	290	5.9	120	-	-	-	-	-	-
B(b+k)F	W	-	-	15	83	-	-	-	-	-	-
	Sp	-	-	8.7	85	-	-	-	-	-	-
	Su	-	-	8.1	93	-	-	-	-	-	-
	F	-	-	16	110	-	-	-	-	-	-
	Annual	-	-	12	99	-	-	-	-	-	-
B(a)P	W	-	-	6.1	120	-	-	-	-	-	-
	Sp	-	-	3.3	120	-	-	-	-	-	-
	Su	-	-	3.8	120	-	-	-	-	-	-
	F	-	-	5.7	140	-	-	-	-	-	-
	Annual	-	-	4.7	130	-	-	-	-	-	-
I(1,2,3-cd)P	W	44	320	13	100	-	-	-	-	-	-
	Sp	35	390	5.4	110	-	-	-	-	-	-
	Su	38	2600	5.7	130	-	-	-	-	-	-
	F	28	37	13	140	-	-	-	-	-	-
	Annual	36	1500	9.3	130	-	-	-	-	-	-
sum-PAH (UN ECE)	W	-	-	34	100	-	-	-	-	-	-
	Sp	-	-	17	100	-	-	-	-	-	-
	Su	-	-	18	110	-	-	-	-	-	-
	F	-	-	35	110	-	-	-	-	-	-
	Annual	-	-	26	110	-	-	-	-	-	-
Pb	W	1400	160	650	170	-	-	-	-	-	-
	Sp	1400	1100	660	150	-	-	-	-	-	-
	Su	320	210	230	130	-	-	-	-	-	-
	F	250	82	790	130	-	-	-	-	-	-
	Annual	840	1600	580	150	-	-	-	-	-	-
As	W	240	97	160	210	-	-	-	-	-	-
	Sp	79	74	280	240	-	-	-	-	-	-
	Su	100	200	16	130	-	-	-	-	-	-
	F	66	46	78	140	-	-	-	-	-	-
	Annual	120	140	130	240	-	-	-	-	-	-
Se	W	280	210	14	210	-	-	-	-	-	-
	Sp	79	2700	80	260	-	-	-	-	-	-
	Su	100	150	1.9	310	-	-	-	-	-	-
	F	120	14	100	160	-	-	-	-	-	-
	Annual	140	90	49	230	-	-	-	-	-	-
Cd	W	100	120	14	240	-	-	-	-	-	-
	Sp	160	1600	14	210	-	-	-	-	-	-
	Su	65	150	2.8	180	-	-	-	-	-	-
	F	39	27	26	170	-	-	-	-	-	-
	Annual	91	1900	14	190	-	-	-	-	-	-

Table C7: Atmospheric Fluxes to Lake Erie for 1995

(a) Banned Organochlorine Pesticides

Species	Season	Lake Erie 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	9.5	190	0.23	160	28	68	-8.6	60	19	77
	Sp	1	93	0.031	150	28	62	-8.3	60	20	78
	Su	0.46	110	0.1	180	22	66	-22	60	-0.13	14000
	F	1.3	220	0.025	130	34	65	-21	60	13	170
	Annual	3.1	280	0.096	190	28	67	-15	60	13	130
dieldrin	W	2	41	1.4	120	1.1	83	-11	59	-10	96
	Sp	0.81	22	2.1	130	3.9	110	-10	59	-6.5	140
	Su	0.87	23	0.58	140	3.3	110	-15	59	-12	110
	F	1.6	86	0.72	100	4	100	-22	59	-18	110
	Annual	1.3	180	1.2	130	3.1	140	-15	59	-12	120
cis-chlordane	W	2.6	11	1	160	1.7	78	-0.54	56	1.2	96
	Sp	0.34	130	0.15	110	1.4	84	-0.48	56	0.96	120
	Su	0.51	68	0.023	150	0.83	84	-0.52	56	0.31	220
	F	0.93	93	0.22	140	1.2	83	-0.84	56	0.37	280
	Annual	1.1	110	0.35	200	1.3	100	-0.6	56	0.7	170
trans-chlordane	W	5.6	95	0.25	130	0.94	81	-0.5	54	0.45	160
	Sp	0.64	140	0.14	100	1.1	93	-0.43	54	0.69	140
	Su	1	82	0.049	170	0.47	80	-0.4	54	0.069	580
	F	0.38	100	0.072	110	0.85	90	-0.69	54	0.16	490
	Annual	1.9	470	0.13	130	0.84	100	-0.5	54	0.34	230
trans-nonachlor	W	0.11	180	0.19	120	0.21	96	-0.47	52	-0.26	150
	Sp	0.035	130	0.078	100	0.3	96	-0.38	52	-0.074	470
	Su	0.074	60	1.3	180	0.11	85	-0.26	52	-0.16	130
	F	0.068	19	0.18	170	0.25	90	-0.5	52	-0.25	150
	Annual	0.072	110	0.43	250	0.22	130	-0.4	52	-0.19	160
p,p'-DDD	W	0.43	31	0.18	110	0.42	68	-	-	-	-
	Sp	0.065	140	0.073	120	0.19	100	-	-	-	-
	Su	0.097	89	0.21	120	0.19	91	-	-	-	-
	F	0.12	170	0.065	130	0.16	120	-	-	-	-
	Annual	0.18	1100	0.13	130	0.24	180	-	-	-	-
p,p'-DDE	W	2.1	74	0.21	120	1.2	120	-	-	-	-
	Sp	0.31	130	0.12	110	1.9	91	-	-	-	-
	Su	0.28	56	0.12	110	1.2	92	-	-	-	-
	F	0.59	120	0.064	100	1.9	79	-	-	-	-
	Annual	0.83	140	0.13	120	1.6	120	-	-	-	-
p,p'-DDT	W	1.5	19	0.023	140	0.68	160	-	-	-	-
	Sp	0.2	31	0.45	190	1	99	-	-	-	-
	Su	0.52	83	0.11	160	1.3	72	-	-	-	-
	F	4	310	0.046	140	1.6	83	-	-	-	-
	Annual	1.5	280	0.16	240	1.1	100	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Erie 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
g-HCH (lindane)	W	2.6	190	0.054	140	3.1	80	-1.6	110	1.5	160
	Sp	2.2	96	0.12	140	11	120	-1.5	110	9.6	140
	Su	0.38	77	0.044	180	9.3	70	-3.8	110	5.5	120
	F	0.37	230	0.04	130	6.1	67	-3.5	110	2.6	180
	Annual	1.4	200	0.064	140	7.4	110	-2.6	110	4.8	160
a-endosulphan	W	1.5	170	1.5	110	1.5	79	-0.033	100	1.5	62
	Sp	0.85	110	1.8	130	9.8	130	-0.03	100	9.8	130
	Su	1.3	200	3.4	150	110	90	-0.035	100	110	90
	F	0.24	280	0.88	120	10	120	-0.041	100	10	120
	Annual	0.98	190	1.9	150	32	200	-0.035	100	32	200
b-endosulphan	W	1.9	75	0.61	160	0.64	77	-0.00064	99	0.64	58
	Sp	1.3	66	0.82	120	2.4	170	-0.00063	99	2.4	170
	Su	0.64	73	4.6	160	9	98	-0.0026	99	9	98
	F	0.15	330	0.45	130	0.83	130	-0.0019	99	0.83	130
	Annual	0.99	140	1.6	220	3.2	180	-0.0014	99	3.2	180
endosulphan sulphate	W	7.8	220	-	-	-	-	-	-	-	-
	Sp	0.7	81	-	-	-	-	-	-	-	-
	Su	1.3	110	-	-	-	-	-	-	-	-
	F	0.25	55	-	-	-	-	-	-	-	-
	Annual	2.5	300	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Erie 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
HCB	W	0.18	12	0.044	100	4.6	65	-3.3	280	1.2	340
	Sp	0.033	51	0.019	110	3.3	62	-2.6	280	0.77	460
	Su	0.037	27	0.016	100	0.79	61	-1.6	280	-0.83	260
	F	0.057	88	0.014	100	1.6	61	-3.2	280	-1.6	260
	Annual	0.078	91	0.023	110	2.6	64	-2.7	280	-0.11	630
PCB18	W	0.29	120	0.11	100	0.48	86	-3.4	65	-2.9	110
	Sp	0.057	32	0.047	100	0.49	72	-2.6	65	-2.2	110
	Su	0.17	34	0.063	100	0.24	68	-1.7	65	-1.5	110
	F	0.075	100	0.037	100	0.31	79	-3.3	65	-3	100
	Annual	0.15	79	0.064	110	0.38	94	-2.8	65	-2.4	110
PCB44	W	0.22	56	0.22	180	0.85	120	-2.4	59	-1.5	150
	Sp	0.069	27	0.055	100	1	76	-1.9	59	-0.91	180
	Su	0.083	40	0.099	110	0.84	72	-1.4	59	-0.53	210
	F	0.039	38	0.12	160	0.93	110	-2.6	59	-1.6	140
	Annual	0.1	97	0.12	160	0.91	120	-2.1	59	-1.2	180
PCB52	W	0.37	61	0.3	160	0.76	82	-2	85	-1.2	160
	Sp	0.092	27	0.096	100	0.96	69	-1.6	85	-0.67	240
	Su	0.16	23	0.1	100	0.91	81	-1.2	85	-0.33	380
	F	0.11	72	0.064	110	0.82	80	-2.3	85	-1.4	160
	Annual	0.18	91	0.14	170	0.86	120	-1.8	85	-0.92	320
PCB101	W	0.34	64	0.43	180	0.38	88	-1	96	-0.66	160
	Sp	0.065	30	0.05	100	0.47	71	-0.87	96	-0.39	220
	Su	0.095	29	0.051	100	0.39	84	-0.69	96	-0.3	240
	F	0.078	96	0.049	110	0.37	82	-1.3	96	-0.89	150
	Annual	0.14	94	0.14	250	0.41	130	-0.97	96	-0.56	280
Sum-PCB	W	15	36	8.2	150	12	86	-40	82	-29	140
	Sp	2.6	28	2	100	12	70	-32	82	-20	160
	Su	4.7	28	1.7	100	9	72	-23	82	-14	160
	F	2.2	97	1.5	100	9.3	78	-42	82	-33	130
	Annual	6.2	80	3.4	180	11	110	-34	82	-24	160

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Erie 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	170	59	32	110	1000	68	-480	110	520	130
	Sp	6.9	65	13	120	570	82	-430	110	140	410
	Su	14	93	8.1	130	730	69	-520	110	210	300
	F	35	190	16	110	590	90	-740	110	-160	540
	Annual	57	170	17	120	720	95	-550	110	180	380
PYR	W	100	59	36	120	120	120	-53	88	67	210
	Sp	8	68	21	110	52	100	-49	88	3.4	1900
	Su	12	140	13	120	120	69	-78	88	44	220
	F	31	180	23	100	99	140	-91	88	7.8	2000
	Annual	39	130	23	120	98	110	-68	88	31	350
B(b+k)F	W	160	50	110	99	11	100	-1.1	170	9.9	110
	Sp	16	52	47	80	11	88	-1	170	10	95
	Su	25	85	42	120	3.7	64	-4.1	170	-0.43	1500
	F	41	84	50	92	5.5	64	-3.2	170	2.3	240
	Annual	60	99	62	97	7.8	93	-2.3	170	5.5	130
B(a)P	W	52	59	15	120	2.6	71	-1.1	120	1.5	120
	Sp	4.8	73	10	100	3.5	84	-1.1	120	2.4	120
	Su	8.5	110	8	130	1.4	68	-4.2	120	-2.8	160
	F	15	110	11	100	2	68	-3.4	120	-1.4	260
	Annual	20	110	11	110	2.4	82	-2.4	120	-0.08	1100
I(1,2,3-cd)P	W	100	59	41	130	2.2	100	-0.00025	240	2.2	100
	Sp	6.8	58	13	110	1.2	69	-0.00024	240	1.2	69
	Su	8.6	110	13	140	0.94	68	-0.00099	240	0.93	68
	F	21	110	27	110	1.3	68	-0.00075	240	1.3	68
	Annual	35	150	23	130	1.4	84	-0.00056	240	1.4	84
sum-PAH (UN ECE)	W	310	34	160	110	16	72	-2.2	100	14	82
	Sp	27	36	70	100	16	65	-2.2	100	14	74
	Su	42	62	63	120	5.9	44	-8.2	100	-2.3	350
	F	78	60	88	100	8.7	44	-6.5	100	2.2	310
	Annual	120	70	96	110	12	65	-4.8	100	6.8	110
Pb	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
As	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Se	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Cd	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

Table C8: Atmospheric Fluxes to Lake Erie for 1996

(a) Banned Organochlorine Pesticides

Species	Season	Lake Erie 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %	Mean ng/m^2/d	COV %
a-HCH	W	1	190	-	-	25	72	-7.8	60	17	86
	Sp	0.9	100	-	-	21	63	-7.6	60	14	89
	Su	0.4	140	-	-	16	70	-21	60	-4.3	410
	F	0.38	120	-	-	12	67	-20	60	-7.8	210
	Annual	0.67	130	-	-	19	74	-14	60	4.7	280
dieldrin	W	1.2	500	-	-	0.74	140	-11	59	-10	93
	Sp	2	75	-	-	3.7	160	-9.7	59	-6	160
	Su	0.67	77	-	-	2.3	63	-16	59	-13	100
	F	0.12	350	-	-	2	87	-20	59	-18	97
	Annual	1	120	-	-	2.2	120	-14	59	-12	110
cis-chlordane	W	0.39	180	-	-	0.63	97	-0.55	56	0.074	940
	Sp	0.18	63	-	-	0.92	100	-0.45	56	0.47	200
	Su	0.022	63	-	-	0.57	62	-0.54	56	0.026	1700
	F	0.057	61	-	-	0.7	85	-0.8	56	-0.098	760
	Annual	0.16	130	-	-	0.7	92	-0.59	56	0.12	310
trans-chlordane	W	2	830	-	-	0.4	130	-0.53	54	-0.13	510
	Sp	2.1	110	-	-	0.74	130	-0.4	54	0.33	270
	Su	1.2	24	-	-	0.33	66	-0.42	54	-0.089	360
	F	0.033	69	-	-	0.44	95	-0.65	54	-0.21	270
	Annual	1.4	120	-	-	0.48	100	-0.5	54	-0.024	900
trans-nonachlor	W	0.016	260	-	-	0.15	120	-0.57	52	-0.42	110
	Sp	0.1	45	-	-	0.32	120	-0.37	52	-0.045	940
	Su	0.02	86	-	-	0.11	69	-0.28	52	-0.17	120
	F	0.0063	57	-	-	0.12	90	-0.47	52	-0.35	100
	Annual	0.036	93	-	-	0.17	85	-0.42	52	-0.25	99
p,p'-DDD	W	0.78	840	-	-	1.4	120	-	-	-	-
	Sp	0.041	430	-	-	0.033	58	-	-	-	-
	Su	0.0028	100	-	-	0.19	150	-	-	-	-
	F	0.011	140	-	-	0.59	140	-	-	-	-
	Annual	0.21	330	-	-	0.55	160	-	-	-	-
p,p'-DDE	W	0.18	140	-	-	0.61	110	-	-	-	-
	Sp	0.76	94	-	-	2.4	120	-	-	-	-
	Su	0.13	20	-	-	1.1	74	-	-	-	-
	F	0.032	30	-	-	1.2	85	-	-	-	-
	Annual	0.28	160	-	-	1.3	110	-	-	-	-
p,p'-DDT	W	0.26	11	-	-	0.58	170	-	-	-	-
	Sp	1.3	110	-	-	1.5	100	-	-	-	-
	Su	0.5	120	-	-	5.5	84	-	-	-	-
	F	0.063	110	-	-	0.84	110	-	-	-	-
	Annual	0.52	150	-	-	2.1	160	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Erie 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
g-HCH (lindane)	W	0.4	350	-	-	2.2	69	-1.4	110	0.8	220
	Sp	0.28	54	-	-	7.1	95	-1.4	110	5.8	110
	Su	0.025	130	-	-	17	110	-3.6	110	13	130
	F	0.0078	350	-	-	3.4	71	-3.4	110	0.027	14000
	Annual	0.18	140	-	-	7.4	160	-2.4	110	5	220
a-endosulphan	W	0.25	440	-	-	0.62	120	-0.033	100	0.58	120
	Sp	1.3	100	-	-	7.6	170	-0.029	100	7.6	170
	Su	0.3	110	-	-	56	66	-0.035	100	56	66
	F	0.45	150	-	-	7.4	120	-0.04	100	7.4	120
	Annual	0.57	180	-	-	18	150	-0.034	100	18	150
b-endosulphan	W	0.16	440	-	-	0.18	120	-0.00056	99	0.18	110
	Sp	2.1	130	-	-	0.71	130	-0.00057	99	0.71	130
	Su	0.1	210	-	-	3.8	84	-0.0023	99	3.8	84
	F	0.017	430	-	-	1.1	130	-0.0018	99	1.1	130
	Annual	0.59	300	-	-	1.4	150	-0.0013	99	1.4	150
endosulphan sulphate	W	0.37	620	-	-	-	-	-	-	-	-
	Sp	0.062	90	-	-	-	-	-	-	-	-
	Su	0.17	120	-	-	-	-	-	-	-	-
	F	0.023	300	-	-	-	-	-	-	-	-
	Annual	0.16	170	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Erie 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
HCB	W	0.033	270	-	-	4.3	60	-4.1	280	0.19	2600
	Sp	0.086	120	-	-	2.7	63	-2.5	280	0.21	1600
	Su	0.017	84	-	-	0.77	60	-1.7	280	-0.96	240
	F	0.0085	84	-	-	1.1	61	-3	280	-1.9	210
	Annual	0.036	150	-	-	2.2	64	-2.8	280	-0.61	390
PCB18	W	0.044	230	-	-	0.28	79	-4.1	65	-3.8	96
	Sp	0.092	140	-	-	0.26	75	-2.6	65	-2.3	100
	Su	0.036	93	-	-	0.057	75	-1.8	65	-1.8	97
	F	0.012	120	-	-	0.18	70	-3.1	65	-3	99
	Annual	0.046	130	-	-	0.19	86	-2.9	65	-2.7	100
PCB44	W	0.022	32	-	-	0.64	190	-2.8	59	-2.2	120
	Sp	0.072	190	-	-	0.37	75	-1.9	59	-1.5	110
	Su	0.025	90	-	-	0.084	75	-1.5	59	-1.4	93
	F	0.017	180	-	-	0.61	110	-2.4	59	-1.8	120
	Annual	0.034	190	-	-	0.43	110	-2.1	59	-1.7	110
PCB52	W	0.084	400	-	-	0.57	81	-2.3	85	-1.7	130
	Sp	0.12	180	-	-	0.46	75	-1.6	85	-1.1	140
	Su	0.053	85	-	-	0.11	75	-1.3	85	-1.2	110
	F	0.024	150	-	-	0.46	88	-2.1	85	-1.7	130
	Annual	0.069	150	-	-	0.4	100	-1.8	85	-1.4	160
PCB101	W	0.055	350	-	-	0.3	86	-1.2	96	-0.87	130
	Sp	0.079	210	-	-	0.48	75	-0.83	96	-0.35	240
	Su	0.062	140	-	-	0.087	75	-0.73	96	-0.64	120
	F	0.02	130	-	-	0.23	110	-1.2	96	-0.96	130
	Annual	0.054	140	-	-	0.27	110	-0.98	96	-0.71	160
Sum-PCB	W	1.4	300	-	-	7.3	80	-48	82	-41	110
	Sp	2.8	130	-	-	0.35	75	-31	82	-31	100
	Su	2.8	110	-	-	0.081	75	-24	82	-24	100
	F	0.71	190	-	-	5.7	80	-40	82	-34	120
	Annual	1.9	140	-	-	3.3	94	-36	82	-33	120

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Erie 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	25	15	39	100	780	89	-480	110	300	250
	Sp	11	58	29	150	400	78	-410	110	-12	3800
	Su	3.1	110	7.1	100	350	65	-530	110	-180	310
	F	0.45	230	6.7	100	270	92	-710	110	-440	170
	Annual	9.7	210	20	140	450	84	-530	110	-82	1100
PYR	W	16	28	48	100	93	100	-51	88	42	220
	Sp	6.9	55	44	150	40	100	-46	88	-6.2	880
	Su	1.5	73	11	110	44	65	-77	88	-33	230
	F	0.35	210	8.9	100	51	97	-87	88	-37	250
	Annual	6.2	210	28	140	57	100	-65	88	-8.6	18000
B(b+k)F	W	27	130	66	91	4.5	70	-0.92	170	3.6	89
	Sp	30	43	70	110	3.7	58	-0.94	170	2.8	84
	Su	7.4	30	22	79	2.6	61	-3.7	170	-1.1	550
	F	1.8	360	24	84	4	66	-3	170	1	500
	Annual	17	120	46	110	3.7	66	-2.1	170	1.6	180
B(a)P	W	8.2	210	13	100	1.8	69	-1	120	0.85	160
	Sp	11	63	25	160	1.3	58	-1	120	0.33	340
	Su	2.3	51	6.3	110	0.93	64	-3.8	120	-2.9	140
	F	0.38	400	5.8	100	1.4	71	-3.2	120	-1.7	200
	Annual	5.3	110	13	150	1.4	67	-2.2	120	-0.85	390
I(1,2,3-cd)P	W	11	320	29	110	1.1	69	-0.00022	240	1.1	69
	Sp	16	71	51	150	0.84	58	-0.00022	240	0.84	58
	Su	3.7	50	11	110	0.61	70	-0.00089	240	0.61	70
	F	0.65	420	12	110	0.93	70	-0.00071	240	0.93	70
	Annual	8	120	26	150	0.88	69	-0.00051	240	0.88	69
sum-PAH (UN ECE)	W	47	120	110	100	7.5	46	-1.9	100	5.6	64
	Sp	57	34	150	120	5.9	40	-2	100	3.9	67
	Su	13	25	39	100	4.1	42	-7.5	100	-3.3	220
	F	2.9	260	42	100	6.4	45	-6.2	100	0.22	2800
	Annual	30	76	84	110	6	45	-4.4	100	1.6	180
Pb	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
As	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Se	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-
Cd	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

Table C9: Atmospheric Fluxes to Lake Ontario for 1995

(a) Banned Organochlorine Pesticides

Species	Season	Lake Ontario 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
a-HCH	W	3.3	30	-	-	19	69	-11	56	7.5	170
	Sp	1.9	60	-	-	13	60	-8.3	56	4.9	160
	Su	0.96	29	-	-	12	62	-23	56	-11	160
	F	6.1	47	-	-	19	65	-23	56	-4.7	390
	Annual	3.1	55	-	-	16	64	-16	56	-0.83	4400
dieldrin	W	0.3	120	-	-	1.8	110	-30	57	-28	91
	Sp	0.98	31	-	-	3.2	98	-21	57	-18	100
	Su	0.35	25	-	-	3.1	93	-37	57	-34	93
	F	0.64	59	-	-	3.7	91	-58	57	-54	92
	Annual	0.57	93	-	-	2.9	120	-37	57	-34	95
cis-chlordane	W	0.055	150	-	-	0.7	110	-1.1	50	-0.44	66
	Sp	0.038	47	-	-	0.77	84	-0.81	50	-0.04	1600
	Su	0.017	76	-	-	0.48	93	-1	50	-0.55	120
	F	0.021	81	-	-	0.98	97	-2	50	-1	130
	Annual	0.033	160	-	-	0.73	110	-1.2	50	-0.51	230
trans-chlordane	W	0.025	110	-	-	0.7	120	-1.4	51	-0.67	190
	Sp	0.089	56	-	-	0.65	87	-0.95	51	-0.31	230
	Su	0.017	35	-	-	0.29	97	-1	51	-0.71	96
	F	0.033	76	-	-	0.81	95	-2.2	51	-1.4	110
	Annual	0.041	140	-	-	0.61	110	-1.4	51	-0.77	130
trans-nonachlor	W	0.045	56	-	-	0.38	110	-1.5	54	-1.1	110
	Sp	0.016	450	-	-	0.41	82	-1	54	-0.6	130
	Su	0.03	72	-	-	0.15	94	-0.7	54	-0.55	100
	F	0.012	230	-	-	0.38	95	-1.9	54	-1.6	99
	Annual	0.026	330	-	-	0.33	110	-1.3	54	-0.96	110
p,p'-DDD	W	0.045	65	-	-	0.083	110	-	-	-	-
	Sp	0.11	35	-	-	0.043	98	-	-	-	-
	Su	0.041	50	-	-	0.13	81	-	-	-	-
	F	0.045	92	-	-	0.16	110	-	-	-	-
	Annual	0.06	140	-	-	0.1	110	-	-	-	-
p,p'-DDE	W	0.45	180	-	-	2.1	140	-	-	-	-
	Sp	2.1	52	-	-	2.2	87	-	-	-	-
	Su	0.27	42	-	-	1.4	110	-	-	-	-
	F	0.23	160	-	-	3.2	98	-	-	-	-
	Annual	0.77	160	-	-	2.2	120	-	-	-	-
p,p'-DDT	W	4.9	87	-	-	0.77	150	-	-	-	-
	Sp	2.4	87	-	-	0.61	88	-	-	-	-
	Su	0.47	84	-	-	1.1	110	-	-	-	-
	F	0.14	57	-	-	1.1	100	-	-	-	-
	Annual	2	250	-	-	0.9	130	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Ontario 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
g-HCH (lindane)	W	1.4	48	-	-	2.7	74	-2.2	64	0.47	520
	Sp	4.3	64	-	-	6.4	89	-1.7	64	4.7	110
	Su	1.4	15	-	-	5.7	70	-4.2	64	1.5	290
	F	0.64	59	-	-	4.4	70	-4.3	64	0.19	2100
	Annual	1.9	110	-	-	4.8	90	-3.1	64	1.7	210
a-endosulphan	W	0.33	77	-	-	2.7	95	-0.0095	82	2.7	81
	Sp	7	83	-	-	39	230	-0.0075	82	38	230
	Su	2.2	61	-	-	40	120	-0.0086	82	40	120
	F	0.86	53	-	-	6.6	110	-0.011	82	6.6	110
	Annual	2.6	140	-	-	22	220	-0.0092	82	22	220
b-endosulphan	W	0.5	42	-	-	0.68	190	-0.00054	110	0.68	180
	Sp	6.6	75	-	-	4.9	220	-0.0004	110	4.9	220
	Su	5.6	120	-	-	12	150	-0.0015	110	12	150
	F	0.62	74	-	-	2.5	120	-0.0013	110	2.5	120
	Annual	3.3	140	-	-	5	230	-0.00093	110	5	230
endosulphan sulphate	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

Species	Season	Lake Ontario 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
HCB	W	0.2	100	-	-	6	59	-10	96	-4	250
	Sp	0.075	64	-	-	4.1	61	-6.5	96	-2.4	260
	Su	0.078	57	-	-	0.33	66	-3.9	96	-3.6	120
	F	0.066	82	-	-	2.4	65	-11	96	-8.7	130
	Annual	0.11	160	-	-	3.2	69	-7.9	96	-4.7	150
PCB18	W	0.23	93	-	-	1.5	68	-4.5	51	-3	110
	Sp	0.095	200	-	-	1.1	64	-3	51	-1.9	100
	Su	0.056	63	-	-	0.31	67	-1.9	51	-1.6	83
	F	0.087	82	-	-	1.1	64	-5.2	51	-4.1	87
	Annual	0.12	180	-	-	0.99	67	-3.6	51	-2.6	92
PCB44	W	0.41	140	-	-	0.42	81	-3.8	50	-3.4	75
	Sp	0.36	57	-	-	0.45	63	-2.6	50	-2.1	73
	Su	0.13	28	-	-	0.14	73	-1.9	50	-1.7	69
	F	0.24	130	-	-	0.35	81	-4.8	50	-4.4	69
	Annual	0.28	120	-	-	0.34	81	-3.3	50	-2.9	70
PCB52	W	0.65	130	-	-	0.69	81	-2.5	55	-1.8	120
	Sp	0.36	200	-	-	0.82	65	-1.7	55	-0.87	150
	Su	0.18	14	-	-	0.33	72	-1.3	55	-1	110
	F	0.27	110	-	-	0.77	82	-3.3	55	-2.5	110
	Annual	0.37	210	-	-	0.65	83	-2.2	55	-1.5	120
PCB101	W	0.46	140	-	-	0.34	98	-1.3	53	-0.93	110
	Sp	0.27	140	-	-	0.36	65	-0.87	53	-0.51	130
	Su	0.15	42	-	-	0.12	79	-0.74	53	-0.62	94
	F	0.16	110	-	-	0.31	88	-1.8	53	-1.5	95
	Annual	0.26	170	-	-	0.28	91	-1.2	53	-0.89	100
Sum-PCB	W	8.9	110	-	-	10	71	-51	51	-41	96
	Sp	6.5	78	-	-	12	61	-34	51	-23	100
	Su	2.3	31	-	-	3.6	70	-24	51	-20	85
	F	4.5	88	-	-	11	79	-63	51	-52	87
	Annual	5.6	150	-	-	9.1	76	-43	51	-34	91

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Ontario 1995									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
PHEN	W	20	75	7	120	-	-	-240	81	-	-
	Sp	12	92	3.7	140	-	-	-180	81	-	-
	Su	11	29	1.9	100	-	-	-240	81	-	-
	F	22	450	3.4	120	-	-	-390	81	-	-
	Annual	16	160	4	140	-	-	-260	81	-	-
PYR	W	28	66	13	150	-	-	-36	86	-	-
	Sp	13	100	6.4	180	-	-	-27	86	-	-
	Su	11	45	2.8	140	-	-	-46	86	-	-
	F	21	340	4.6	120	-	-	-59	86	-	-
	Annual	18	160	6.7	160	-	-	-42	86	-	-
B(b+k)F	W	38	38	31	140	-	-	-0.74	98	-	-
	Sp	19	91	13	110	-	-	-0.55	98	-	-
	Su	14	22	6.6	100	-	-	-2	98	-	-
	F	29	240	9	85	-	-	-1.7	98	-	-
	Annual	25	120	15	140	-	-	-1.3	98	-	-
B(a)P	W	10	58	6.2	140	-	-	-1.1	59	-	-
	Sp	8.2	99	4.3	160	-	-	-0.83	59	-	-
	Su	6.8	44	2.9	140	-	-	-3	59	-	-
	F	11	400	3.6	110	-	-	-2.6	59	-	-
	Annual	9.1	160	4.2	140	-	-	-1.9	59	-	-
I(1,2,3-cd)P	W	15	57	17	140	-	-	-	-	-	-
	Sp	8	120	11	140	-	-	-	-	-	-
	Su	8	34	5.1	120	-	-	-	-	-	-
	F	11	450	7.7	110	-	-	-	-	-	-
	Annual	10	190	10	140	-	-	-	-	-	-
sum-PAH (UN ECE)	W	64	30	55	120	-	-	-	-	-	-
	Sp	35	60	28	110	-	-	-	-	-	-
	Su	29	20	15	110	-	-	-	-	-	-
	F	51	190	20	100	-	-	-	-	-	-
	Annual	45	89	30	120	-	-	-	-	-	-
Pb	W	1400	410	630	140	-	-	-	-	-	-
	Sp	800	76	630	120	-	-	-	-	-	-
	Su	780	700	360	130	-	-	-	-	-	-
	F	1400	140	260	110	-	-	-	-	-	-
	Annual	1100	600	470	130	-	-	-	-	-	-
As	W	150	240	34	160	-	-	-	-	-	-
	Sp	120	110	34	120	-	-	-	-	-	-
	Su	73	910	22	150	-	-	-	-	-	-
	F	210	150	31	120	-	-	-	-	-	-
	Annual	140	400	30	170	-	-	-	-	-	-
Se	W	190	190	27	240	-	-	-	-	-	-
	Sp	150	160	5.2	170	-	-	-	-	-	-
	Su	96	570	32	190	-	-	-	-	-	-
	F	300	160	23	190	-	-	-	-	-	-
	Annual	190	590	22	220	-	-	-	-	-	-
Cd	W	110	170	14	180	-	-	-	-	-	-
	Sp	47	70	10	150	-	-	-	-	-	-
	Su	79	690	3.6	180	-	-	-	-	-	-
	F	66	88	-	-	-	-	-	-	-	-
	Annual	76	660	7.1	200	-	-	-	-	-	-

Table C10: Atmospheric Fluxes to Lake Ontario for 1996

(a) Banned Organochlorine Pesticides

Species	Season	Lake Ontario 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
a-HCH	W	5	27	-	-	17	61	-10	56	6.6	160
	Sp	5.2	25	-	-	12	61	-7.9	56	4.4	170
	Su	2	47	-	-	11	59	-19	56	-8.4	170
	F	5.7	42	-	-	11	60	-20	56	-8.7	180
	Annual	4.5	55	-	-	13	62	-14	56	-1.5	620
dieldrin	W	0.34	260	-	-	1.4	88	-27	57	-26	90
	Sp	0.83	26	-	-	2.7	100	-21	57	-18	98
	Su	0.34	39	-	-	2.9	70	-36	57	-33	93
	F	1.1	91	-	-	2	91	-48	57	-46	90
	Annual	0.65	74	-	-	2.3	99	-33	57	-31	94
cis-chlordane	W	0.046	230	-	-	0.41	79	-1.1	50	-0.67	66
	Sp	0.085	31	-	-	0.82	100	-0.8	50	0.022	3600
	Su	0.033	31	-	-	0.71	69	-1	50	-0.33	180
	F	0.091	100	-	-	0.66	77	-1.6	50	-0.95	98
	Annual	0.063	64	-	-	0.65	97	-1.1	50	-0.48	260
trans-chlordane	W	0.057	120	-	-	0.41	87	-1.3	51	-0.89	110
	Sp	0.07	97	-	-	0.71	110	-0.95	51	-0.25	350
	Su	0.026	120	-	-	0.43	70	-1	51	-0.62	110
	F	0.07	32	-	-	0.4	76	-1.7	51	-1.3	87
	Annual	0.056	72	-	-	0.49	96	-1.3	51	-0.77	130
trans-nonachlor	W	0.098	270	-	-	0.24	83	-1.5	54	-1.3	98
	Sp	0.55	110	-	-	0.38	110	-1.1	54	-0.69	130
	Su	0.089	93	-	-	0.19	71	-0.76	54	-0.57	100
	F	0.36	130	-	-	0.17	84	-1.5	54	-1.3	91
	Annual	0.27	160	-	-	0.25	100	-1.2	54	-0.96	110
p,p'-DDD	W	0.096	210	-	-	0.04	60	-	-	-	-
	Sp	0.11	22	-	-	0.17	74	-	-	-	-
	Su	0.035	17	-	-	0.17	71	-	-	-	-
	F	0.1	70	-	-	0.097	78	-	-	-	-
	Annual	0.086	53	-	-	0.12	93	-	-	-	-
p,p'-DDE	W	0.34	43	-	-	1.1	86	-	-	-	-
	Sp	0.46	58	-	-	2.3	110	-	-	-	-
	Su	0.17	44	-	-	2.2	80	-	-	-	-
	F	0.18	14	-	-	1.1	78	-	-	-	-
	Annual	0.29	67	-	-	1.7	120	-	-	-	-
p,p'-DDT	W	0.45	150	-	-	0.3	94	-	-	-	-
	Sp	0.98	100	-	-	1.2	130	-	-	-	-
	Su	0.28	85	-	-	2.6	77	-	-	-	-
	F	0.63	53	-	-	0.99	79	-	-	-	-
	Annual	0.59	91	-	-	1.3	130	-	-	-	-

(b) Current-use Pesticides

Species	Season	Lake Ontario 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
g-HCH (lindane)	W	1.9	21	-	-	2.3	63	-2.1	64	0.27	750
	Sp	6.7	41	-	-	4.7	97	-1.6	64	3.1	140
	Su	2.3	95	-	-	11	100	-3.5	64	7.5	150
	F	4	30	-	-	2.6	69	-3.7	64	-1.1	290
	Annual	3.7	63	-	-	5.2	150	-2.7	64	2.5	270
a-endosulphan	W	0.55	230	-	-	1.7	64	-0.0095	82	1.6	40
	Sp	1.7	45	-	-	11	170	-0.0077	82	11	170
	Su	5.9	180	-	-	51	85	-0.0084	82	51	85
	F	0.85	49	-	-	6.1	180	-0.0099	82	6.1	180
	Annual	2.3	220	-	-	18	170	-0.0089	82	17	170
b-endosulphan	W	0.64	49	-	-	0.077	88	-0.00049	110	0.076	73
	Sp	2.2	66	-	-	1.9	130	-0.00037	110	1.9	130
	Su	1.6	250	-	-	9.2	82	-0.0012	110	9.2	82
	F	1.1	55	-	-	1	170	-0.0011	110	1	170
	Annual	1.4	150	-	-	3	160	-0.00079	110	3	160
endosulphan sulphate	W	-	-	-	-	-	-	-	-	-	-
	Sp	-	-	-	-	-	-	-	-	-	-
	Su	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Annual	-	-	-	-	-	-	-	-	-	-

(c) Banned Organochlorine Commercial Chemicals

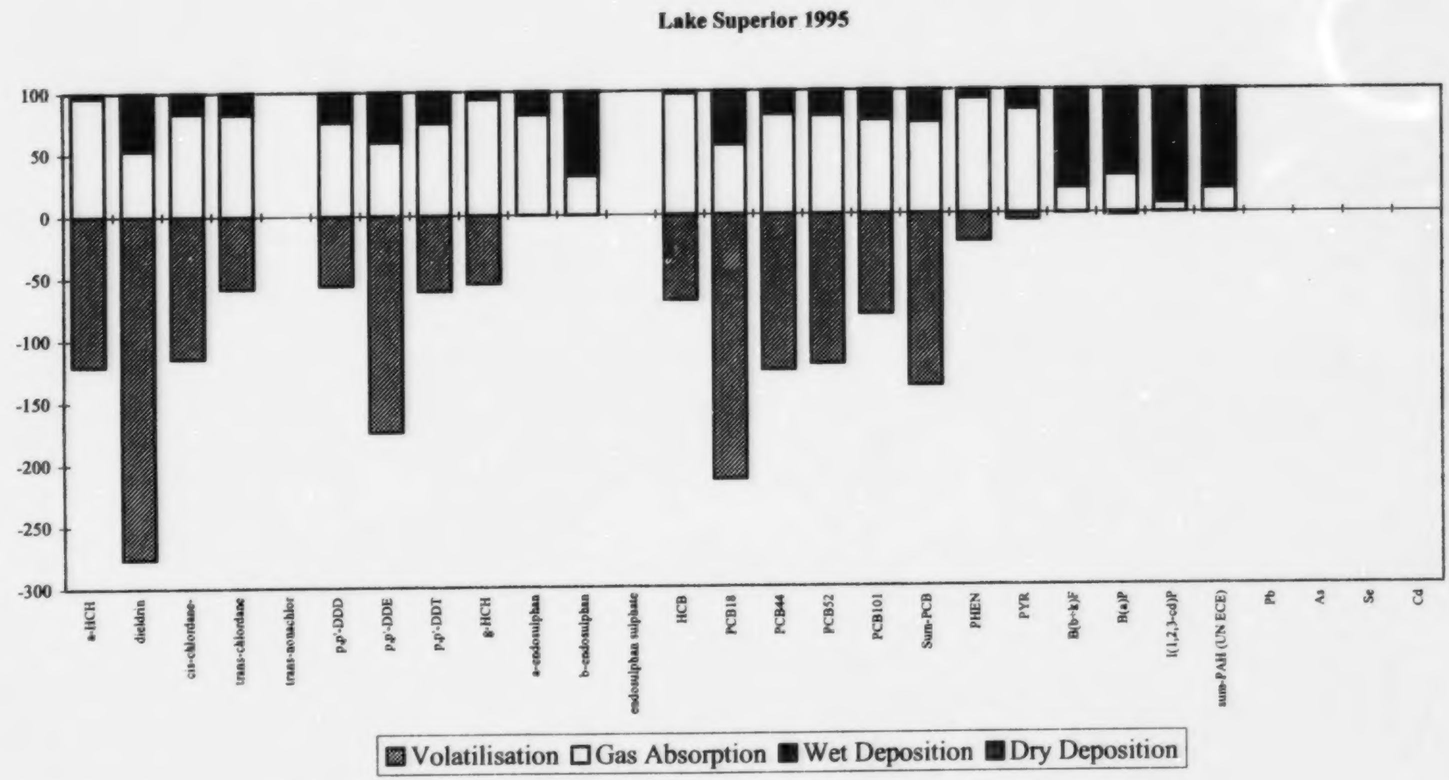
Species	Season	Lake Ontario 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %	Mean ng/m²/d	COV %
HCB	W	0.16	210	-	-	6.9	59	-10	96	-3.4	300
	Sp	0.12	300	-	-	4.8	61	-7.1	96	-2.3	310
	Su	0.16	89	-	-	0.59	67	-4.3	96	-3.7	120
	F	0.066	24	-	-	1.5	64	-8.3	96	-6.8	130
	Annual	0.13	130	-	-	3.4	67	-7.5	96	-4.1	150
PCB18	W	0.12	180	-	-	1.9	61	-4.6	51	-2.7	130
	Sp	0.082	300	-	-	1.2	79	-3.2	51	-2	110
	Su	0.13	80	-	-	0.45	69	-2.1	51	-1.6	88
	F	0.077	56	-	-	0.72	110	-3.9	51	-3.2	87
	Annual	0.1	110	-	-	1.1	83	-3.4	51	-2.4	94
PCB44	W	0.27	190	-	-	0.34	74	-3.8	50	-3.5	73
	Sp	0.21	280	-	-	0.36	84	-2.7	50	-2.4	72
	Su	0.15	56	-	-	0.21	71	-2	50	-1.8	70
	F	0.16	44	-	-	0.24	97	-3.7	50	-3.4	69
	Annual	0.2	130	-	-	0.29	91	-3	50	-2.8	70
PCB52	W	0.51	200	-	-	0.69	74	-2.4	55	-1.8	120
	Sp	0.32	300	-	-	0.94	81	-1.8	55	-0.82	170
	Su	0.31	62	-	-	0.51	69	-1.4	55	-0.93	120
	F	0.29	41	-	-	0.58	86	-2.5	55	-2	110
	Annual	0.36	110	-	-	0.68	88	-2	55	-1.4	130
PCB101	W	0.26	230	-	-	0.25	75	-1.2	53	-0.98	100
	Sp	0.21	270	-	-	0.46	93	-0.89	53	-0.43	170
	Su	0.12	41	-	-	0.23	69	-0.79	53	-0.56	110
	F	0.19	33	-	-	0.27	72	-1.4	53	-1.1	96
	Annual	0.19	130	-	-	0.3	91	-1.1	53	-0.78	120
Sum-PCB	W	5.1	230	-	-	9.9	69	-51	51	-41	95
	Sp	3.7	270	-	-	7.6	82	-36	51	-29	90
	Su	3	52	-	-	4.2	71	-26	51	-22	86
	F	3.3	29	-	-	5.5	110	-48	51	-43	83
	Annual	3.8	120	-	-	6.8	90	-40	51	-34	87

(d) Currently-Emitted PAHs and Metals

Species	Season	Lake Ontario 1996									
		Wet Deposition		Dry Deposition		Gas Exchange					
						Gas Absorption		Volatilisation		Net Gas Exchange	
		Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %	Mean $ng/m^2/d$	COV %
PHEN	W	39	130	19	120	-	-	-230	81	-	-
	Sp	64	110	5.1	170	-	-	-180	81	-	-
	Su	7.8	77	3.5	130	-	-	-240	81	-	-
	F	35	170	8.5	130	-	-	-320	81	-	-
	Annual	37	140	9.1	150	-	-	-240	81	-	-
PYR	W	28	210	26	120	-	-	-34	86	-	-
	Sp	75	140	4.8	150	-	-	-27	86	-	-
	Su	7.8	160	4.4	130	-	-	-43	86	-	-
	F	40	89	13	140	-	-	-51	86	-	-
	Annual	38	170	12	150	-	-	-39	86	-	-
B(b+k)F	W	42	160	56	100	-	-	-0.67	98	-	-
	Sp	79	210	10	110	-	-	-0.51	98	-	-
	Su	11	28	12	130	-	-	-1.6	98	-	-
	F	46	64	63	170	-	-	-1.5	98	-	-
	Annual	44	200	36	170	-	-	-1.1	98	-	-
B(a)P	W	18	180	14	110	-	-	-1	59	-	-
	Sp	27	240	3.4	140	-	-	-0.78	59	-	-
	Su	2.7	100	3.8	140	-	-	-2.4	59	-	-
	F	14	36	13	170	-	-	-2.3	59	-	-
	Annual	15	230	8.6	160	-	-	-1.6	59	-	-
I(1,2,3-cd)P	W	26	200	29	110	-	-	-	-	-	-
	Sp	51	150	6.7	120	-	-	-	-	-	-
	Su	3.2	110	4.6	210	-	-	-	-	-	-
	F	15	48	37	160	-	-	-	-	-	-
	Annual	24	260	19	170	-	-	-	-	-	-
sum-PAH (UN ECE)	W	85	110	99	110	-	-	-	-	-	-
	Sp	160	120	21	110	-	-	-	-	-	-
	Su	16	34	20	130	-	-	-	-	-	-
	F	76	42	110	140	-	-	-	-	-	-
	Annual	84	150	63	140	-	-	-	-	-	-
Pb	W	1000	810	790	120	-	-	-	-	-	-
	Sp	680	310	500	110	-	-	-	-	-	-
	Su	700	190	800	110	-	-	-	-	-	-
	F	460	68	880	120	-	-	-	-	-	-
	Annual	720	210	740	120	-	-	-	-	-	-
As	W	110	430	150	120	-	-	-	-	-	-
	Sp	82	250	46	140	-	-	-	-	-	-
	Su	59	41	82	110	-	-	-	-	-	-
	F	84	39	77	130	-	-	-	-	-	-
	Annual	84	150	88	130	-	-	-	-	-	-
Se	W	360	710	32	270	-	-	-	-	-	-
	Sp	82	200	14	180	-	-	-	-	-	-
	Su	82	75	79	110	-	-	-	-	-	-
	F	120	51	74	140	-	-	-	-	-	-
	Annual	160	84	50	150	-	-	-	-	-	-
Cd	W	62	390	14	140	-	-	-	-	-	-
	Sp	51	190	8.6	130	-	-	-	-	-	-
	Su	49	72	10	130	-	-	-	-	-	-
	F	63	25	26	150	-	-	-	-	-	-
	Annual	56	110	15	150	-	-	-	-	-	-

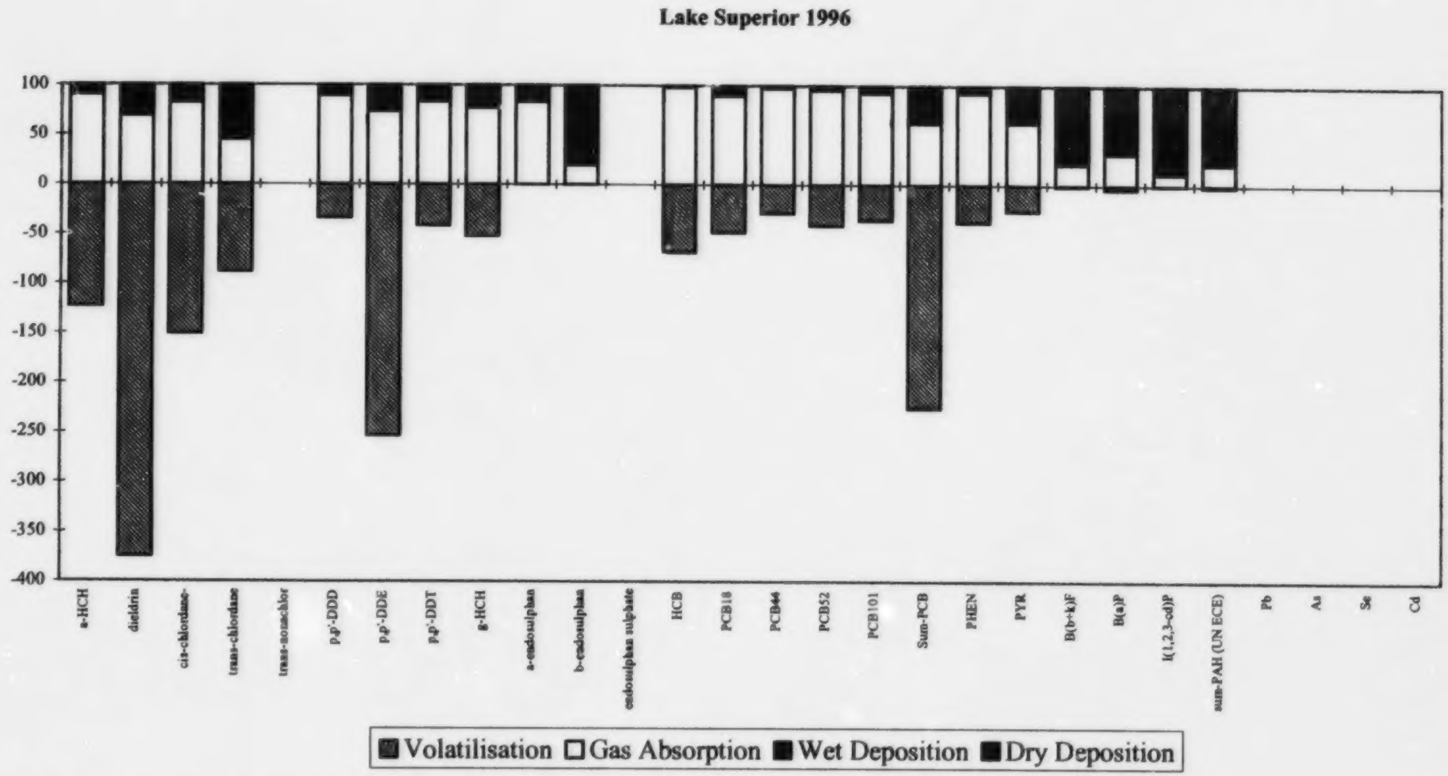
Appendix D: Relative Loadings of IADN Substances

Figure D1: Loadings as a Proportion of Total Deposition to Lake Superior in 1995.



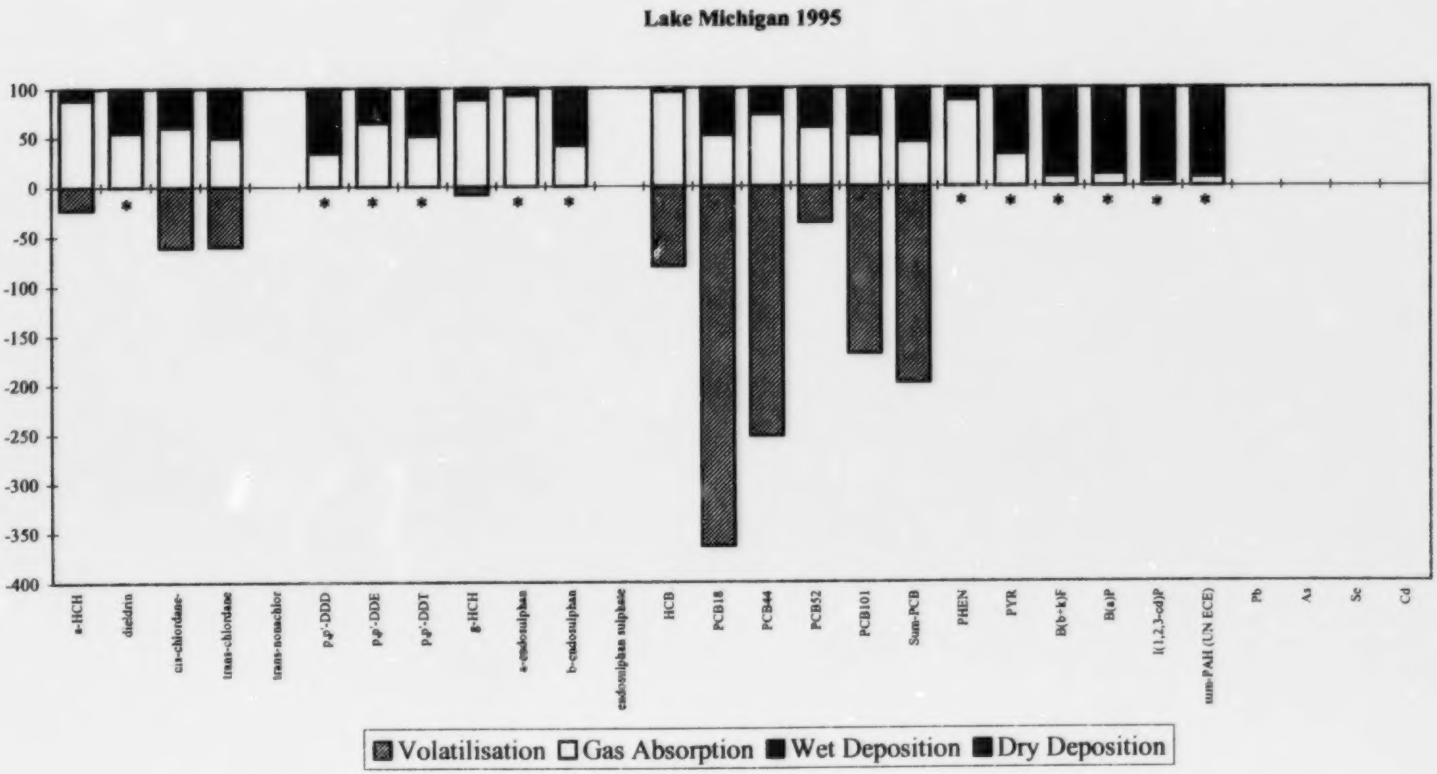
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.

Figure D2: Loadings as a Proportion of Total Deposition to Lake Superior in 1996.



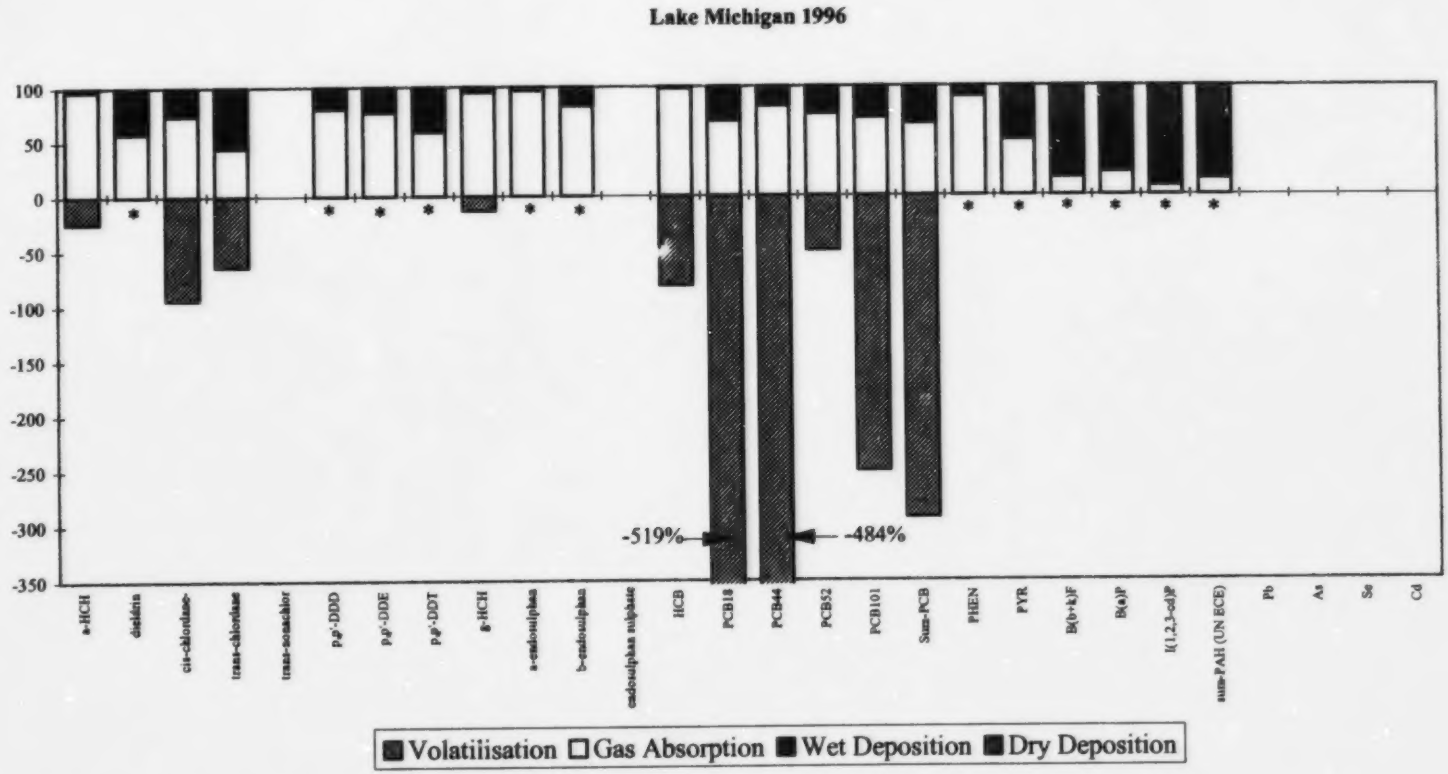
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.

Figure D3: Loadings as a Proportion of Total Deposition to Lake Michigan in 1995.



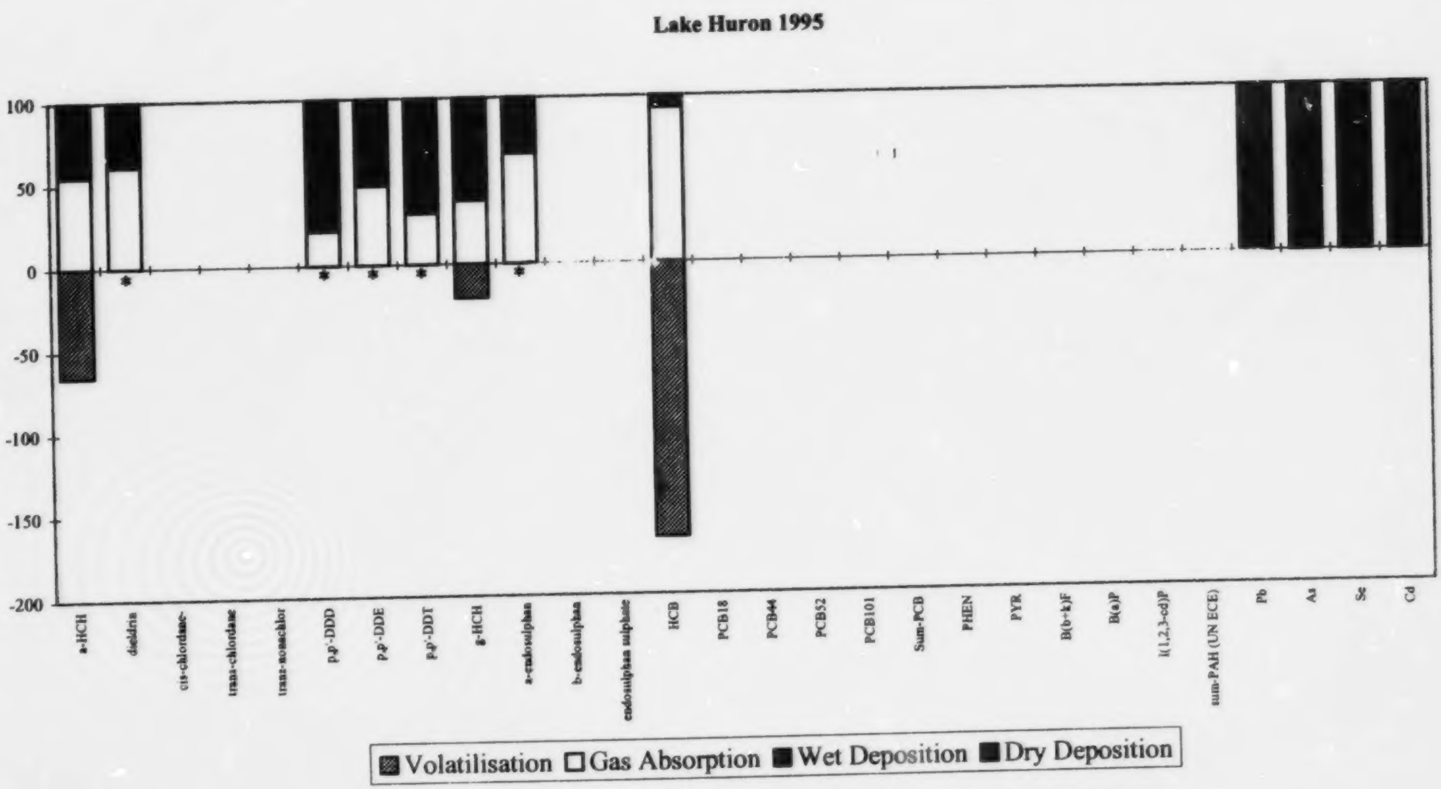
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D4: Loadings as a Proportion of Total Deposition to Lake Michigan in 1996.



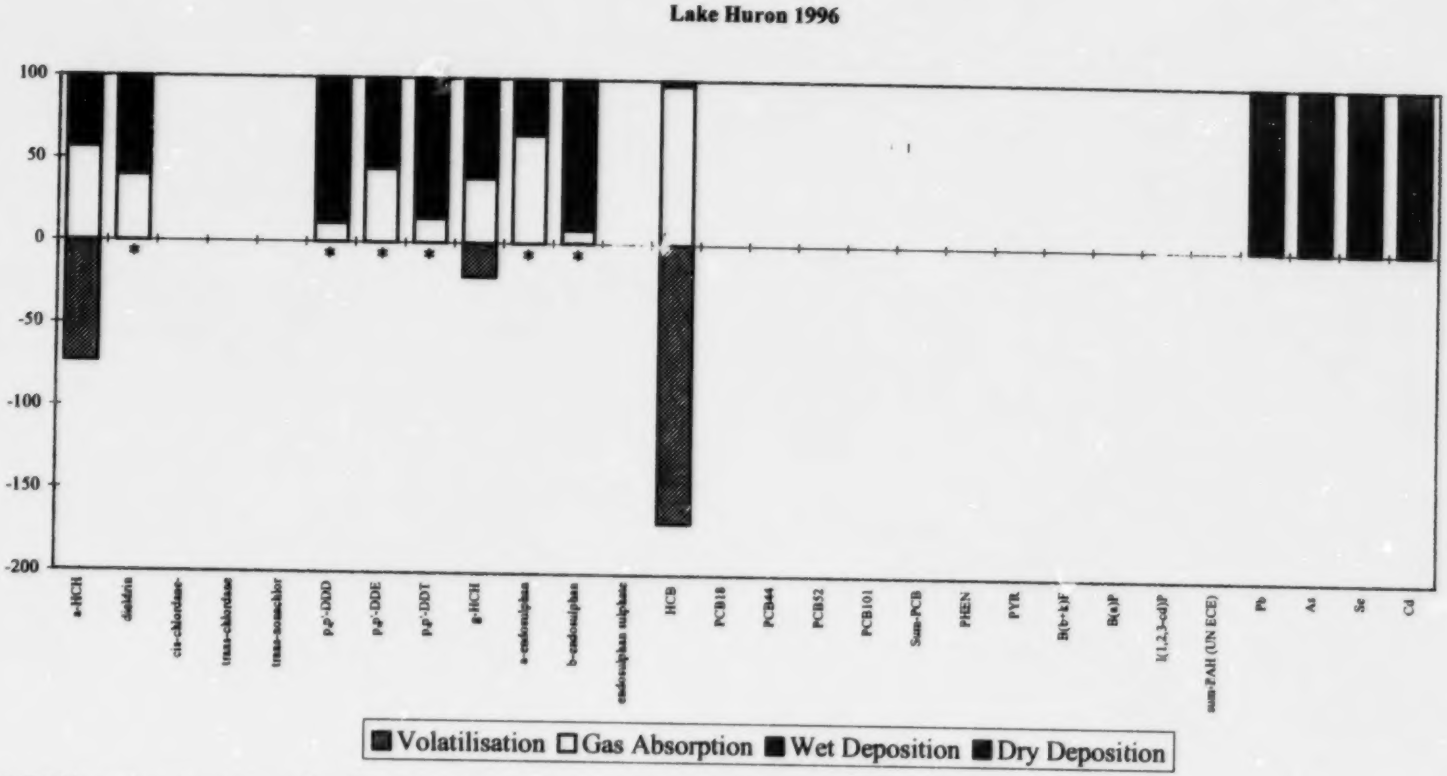
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D5: Loadings as a Proportion of Total Deposition to Lake Huron in 1995.



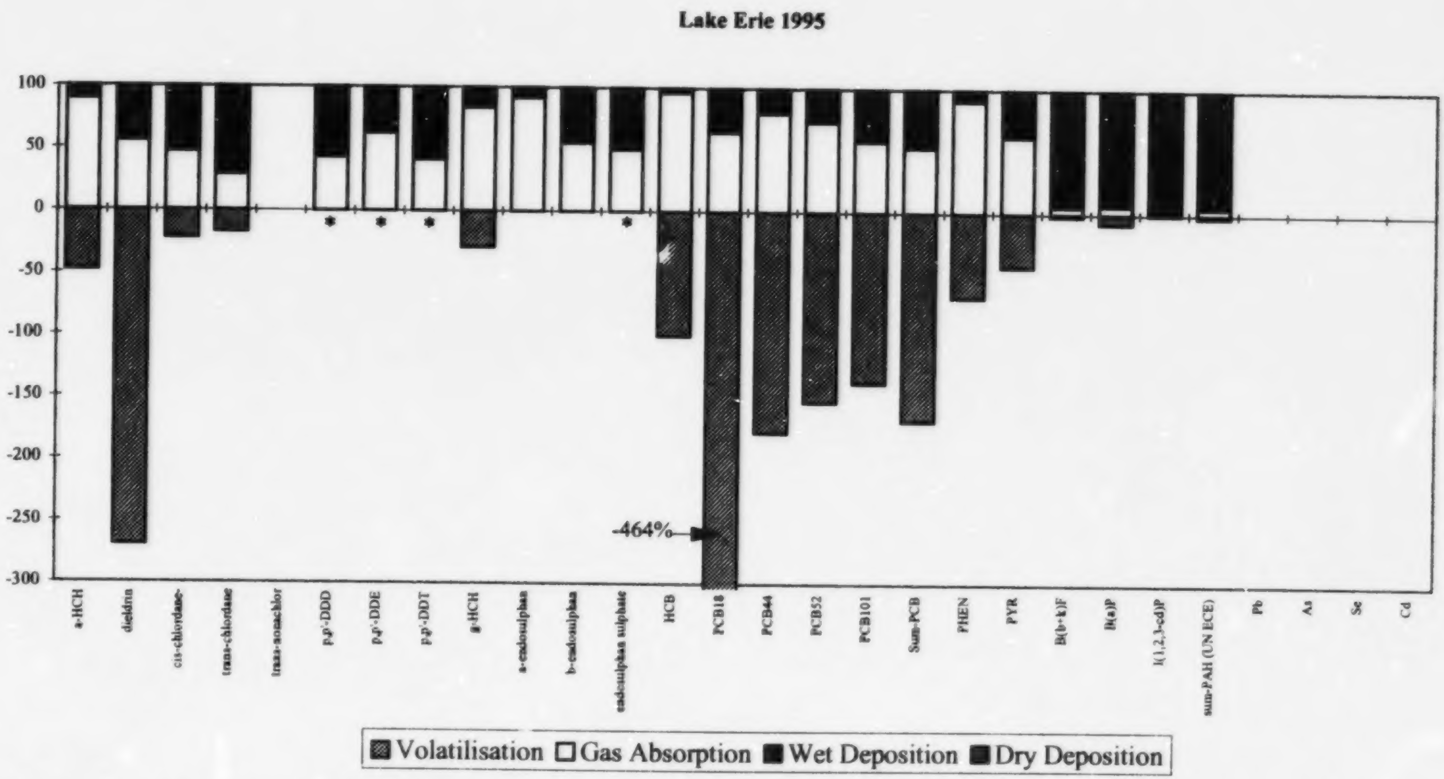
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D6: Loadings as a Proportion of Total Deposition to Lake Huron in 1996.



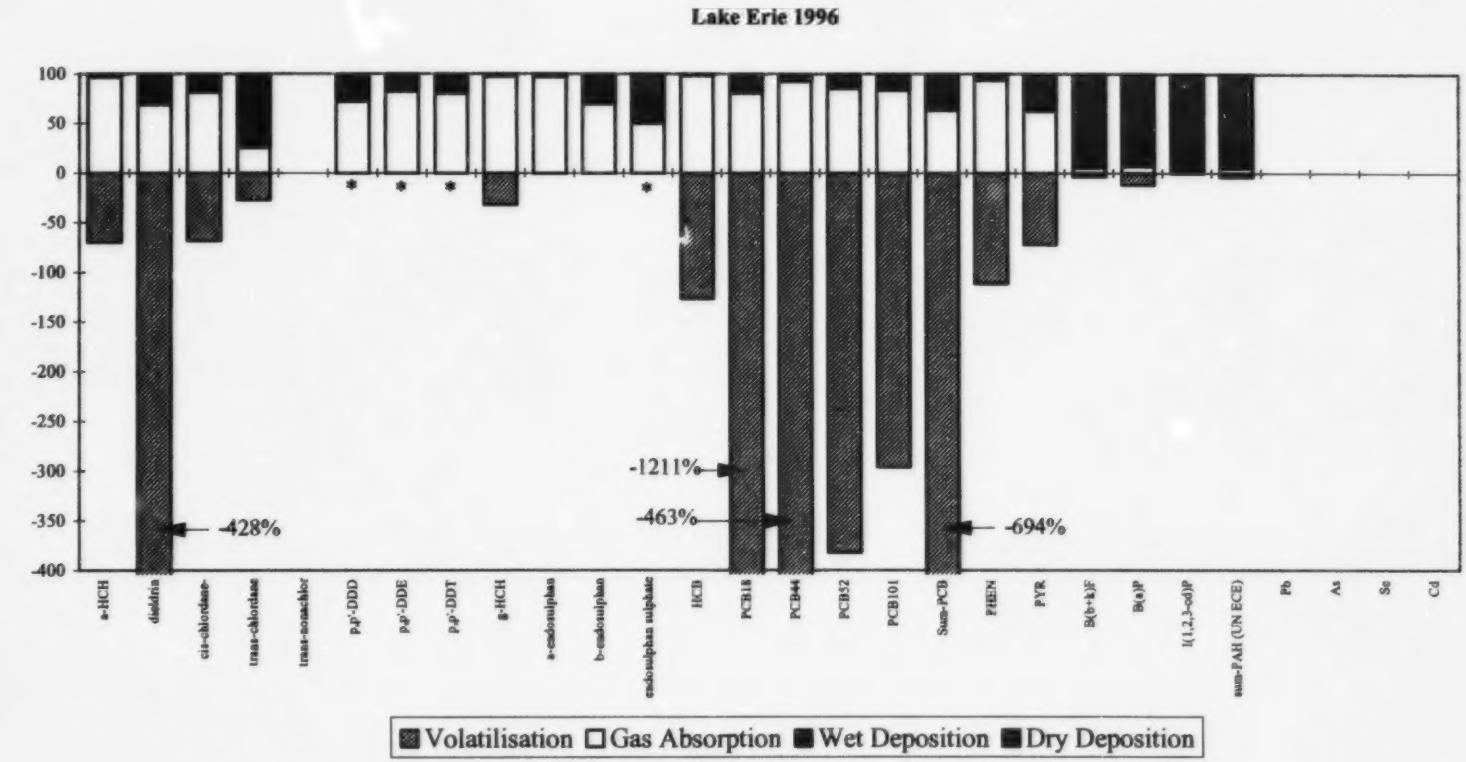
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D7: Loadings as a Proportion of Total Deposition to Lake Erie in 1995.



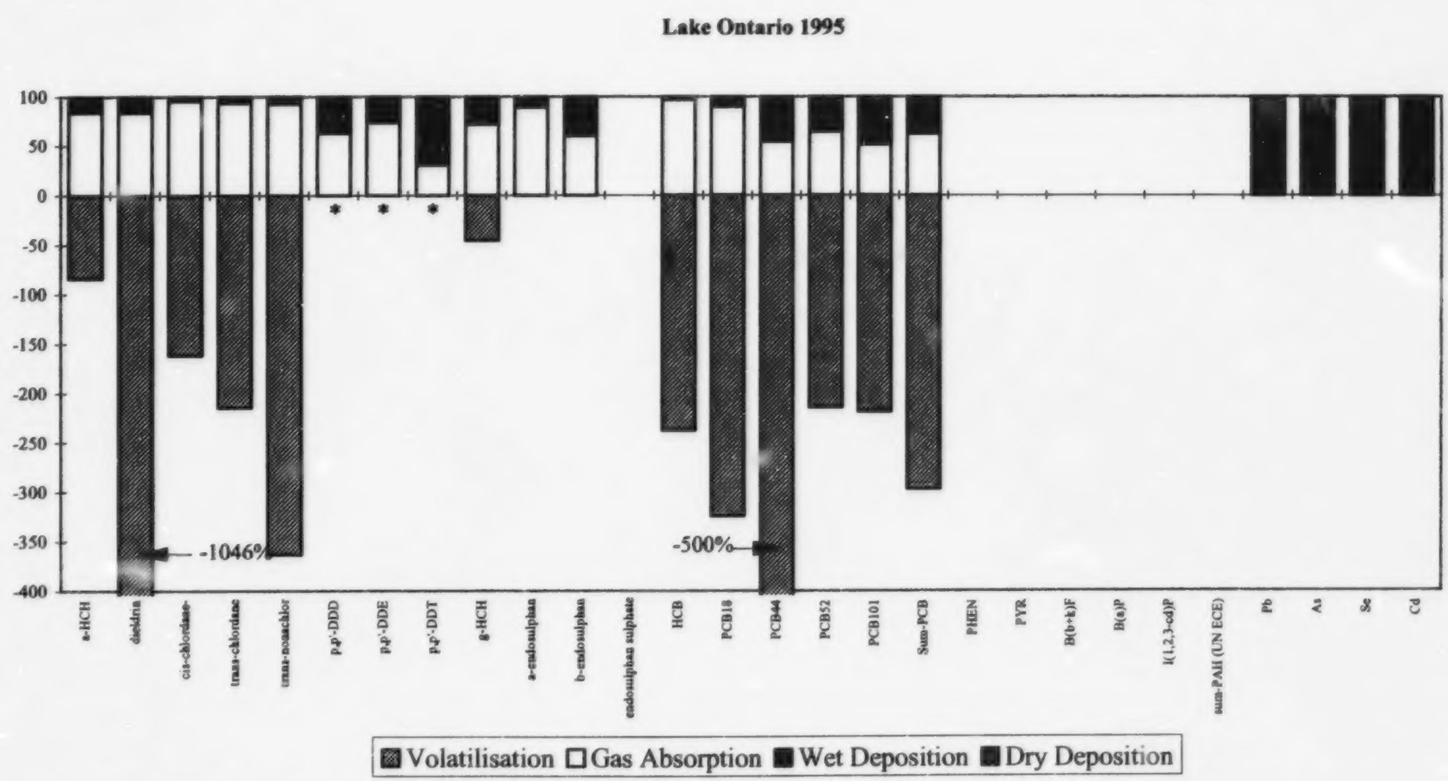
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D8: Loadings as a Proportion of Total Deposition to Lake Erie in 1996.



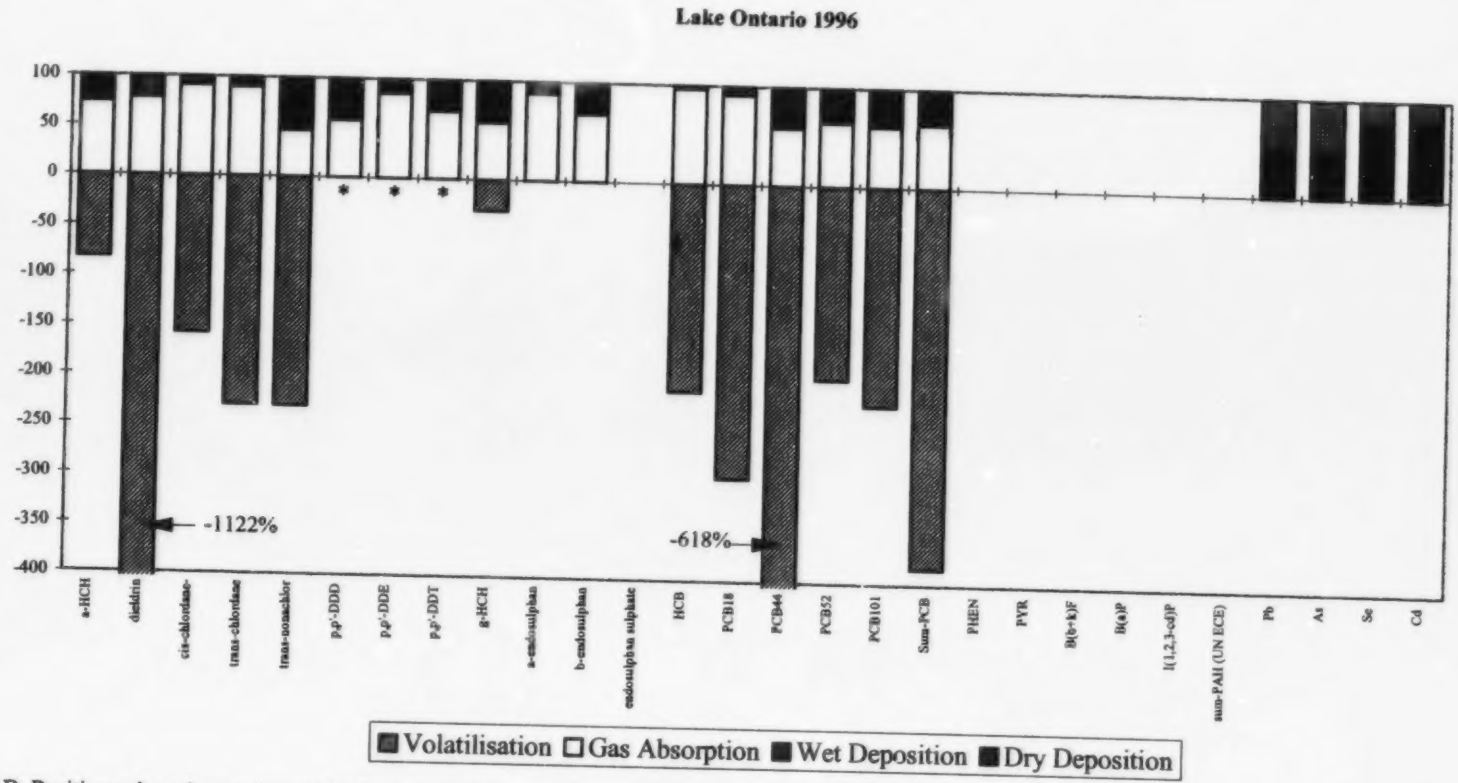
N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D9: Loadings as a Proportion of Total Deposition to Lake Ontario in 1995.



N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimate could be made due to lack of water concentration data

Figure D10: Loadings as a Proportion of Total Deposition to Lake Ontario in 1996.



N.B. Positive values denote deposition from atmosphere to lake. Negative values denote volatilisation from lake to atmosphere.
* indicates substances for which no volatilisation estimates could be made due to lack of water concentration data

Appendix E: Variation in Precipitation and Air Concentration within Lake Basins for 1996

Table E1: 1996 Annual Volume-Weighted Mean Pesticide Concentrations in Precipitation (ng/L)

Lake	Station	Agency	α-HCH	dieldrin	*cis*-chlordane	*trans*-chlordane	*p,p'*-DDD	*p,p'*-DDE	*p,p'*-DDT	γ-HCH	α-endosulphan	β-endosulphan
Superior	Eagle Harbor	EPA/IU	0.76	0.22	0.024	0.11	0.0068	0.016	0.041	0.52	0.49	0.77
	Brule River	EPA/IU	0.77	0.2	0.043	0.034	0.0052	0.024	0.02	0.91	0.43	0.54
	Wolf Ridge	OME	1.2	1.5	0.018	0.018	0.018	0.1	0.018	0.055	-	-
	Sibley	EC EHD	1.6	0.49	0.073	0.066	0.076	0.19	0.13	1.8	0.48	0.74
	Turkey Lakes	EC EHD	1.8	0.3	0.081	0.044	0.089	0.12	0.087	1.5	0.45	1.1
	Mean	***all***	***1.2***	***0.54***	***0.048***	***0.054***	***0.039***	***0.091***	***0.059***	***0.94***	***0.46***	***0.78***
	Master:Mean	***all***	***0.62***	***0.41***	***0.5***	***2***	***0.17***	***0.18***	***0.69***	***0.55***	***1.1***	***0.98***
Michigan	Sleeping Bear Dun	EPA/IU	0.18	0.32	0.047	0.15	0.024	0.052	0.14	0.086	0.25	0.13
	IIT (Chicago)	EPA/IU	0.88	1.3	0.14	0.55	0.11	0.4	1	0.89	0.46	0.39
	Mean	***all***	***0.53***	***0.82***	***0.095***	***0.35***	***0.065***	***0.23***	***0.59***	***0.49***	***0.35***	***0.26***
	Master:Mean	***all***	***0.34***	***0.39***	***0.49***	***0.43***	***0.37***	***0.23***	***0.24***	***0.18***	***0.7***	***0.52***
Huron	Burnt Island	EC EHD	2.4	0.92	0.081	0.086	0.13	0.13	0.18	1.8	0.6	1.1
	Grand Bend	EC EHD	1.9	0.92	0.083	0.068	0.13	0.28	0.77	3.3	0.91	1.7
	Grand Bend	OME	1.2	0.083	0.02	0.02	0.02	0.032	0.12	0.073	-	-
	Mean	***all***	*1.9*	*0.64*	*0.061*	*0.058*	*0.092*	*0.15*	*0.36*	*1.7*	*0.75*	*1.4*
	Master:Mean	***all***	*1.3*	*1.4*	*1.3*	*1.5*	*1.4*	*0.88*	*0.51*	*1.1*	*0.79*	*0.77*
Erie	Sturgeon Point	EPA/IU	0.31	0.31	0.054	0.33	0.0091	0.097	0.2	0.039	0.33	0.19
	Pelee Island	EC EHD	2.4	1.2	0.092	0.076	0.21	2.2	2.7	2.6	0.91	1.6
	Port Stanley	OME	1.3	1.2	0.026	0.026	0.13	0.85	0.026	0.073	-	-
	Rock Point	EC EHD	2.3	0.52	0.06	0.057	0.08	0.36	0.18	1.4	0.7	1.3
	Mean	***all***	*1.6*	*0.82*	*0.058*	*0.12*	*0.11*	*0.87*	*0.77*	*1*	*0.65*	*1*
	Master:Mean	***all***	*0.2*	*0.38*	*0.93*	*2.7*	*0.084*	*0.11*	*0.26*	*0.038*	*0.51*	*0.18*
Ontario	Point Petre	EC EHD	2.1	0.56	0.69	0.073	0.085	0.37	0.23	1.3	1	2.1
	Point Petre	EC NWRI	1.5	0.22	0.022	0.019	0.029	0.1	0.21	1.5	1.6	0.72
	Burlington	EC EHD	3.3	0.78	0.059	0.051	0.14	0.69	1.7	2.7	2.4	4.4
	Metro Zoo (Toront	EC EHD	2.3	0.59	0.067	0.061	0.2	4.5	1.1	2.4	1.2	2
	Mean	***all***	*2.3*	*0.54*	*0.21*	*0.051*	*0.11*	*1.4*	*0.83*	*2*	*1.5*	*2.3*
	Master:Mean	***all***	*0.92*	*1*	*3.3*	*1.4*	*0.76*	*0.26*	*0.28*	*0.66*	*0.66*	*0.91*

Table E2: 1996 Annual Volume-Weighted Mean HCB, PCB and PAH Concentrations in Precipitation (ng/L)

Lake	Station	Agency	HCB	PCB18	PCB44	PCB52	PCB101	PHEN	PYR	B(k)F	B(a)P
Superior	Eagle Harbor	EPA/IU	0.013	0.033	0.016	0.018	0.021	1.4	1	0.63	0.51
	Brule River	EPA/IU	0.014	0.028	0.0099	0.032	0.018	1.4	0.81	0.63	0.49
	Wolf Ridge	OME	0.024	-	-	-	-	10	2.5	3.6	0.71
	Sibley	EC EHD	0.004	-	-	-	-	14	3.3	4.7	6.7
	Turkey Lakes	EC EHD	0.012	-	-	-	-	7.2	8.4	4.1	5.1
	Mean	***all***	***0.013***	***0.031***	***0.013***	***0.025***	***0.019***	***6.8***	***3.2***	***2.7***	***2.7***
	Master:Mean	***all***	***0.96***	***1.1***	***1.2***	***0.72***	***1.1***	***0.21***	***0.32***	***0.23***	***0.19***
Michigan	Sleeping Bear Dun	EPA/IU	0.012	0.019	0.011	0.023	0.015	1.6	1	0.84	0.79
	IIT (Chicago)	EPA/IU	0.034	0.079	0.095	0.13	0.13	87	99	38	60
	Mean	***all***	***0.023***	***0.049***	***0.053***	***0.075***	***0.074***	***44***	***50***	***19***	***30***
	Master:Mean	***all***	***0.51***	***0.4***	***0.2***	***0.31***	***0.2***	***0.036***	***0.02***	***0.043***	***0.026***
Huron	Burnt Island	EC EHD	0.018	-	-	-	-	6.1	7.2	5.4	8
	Grand Bend	EC EHD	0.002	-	-	-	-	7.2	10	5.1	5.6
	Grand Bend	OME	0.02	-	-	-	-	8	3	4.1	0.82
	Mean	***all***	***0.013***	-	-	-	-	***7.1***	***6.7***	***4.9***	***4.8***
	Master:Mean	***all***	***1.4***	-	-	-	-	***0.86***	***1.1***	***1.1***	***1.7***
Erie	Sturgeon Point	EPA/IU	0.013	0.018	0.017	0.028	0.023	2.5	1.5	1.6	1.5
	Pelee Island	EC EHD	0.15	-	-	-	-	15	12	8	7.7
	Port Stanley	OME	0.096	-	-	-	-	18	8.4	5.9	2.3
	Rock Point	EC EHD	0.073	-	-	-	-	9.7	7.1	4.8	5.3
	Mean	***all***	*0.083*	*0.018*	*0.017*	*0.028*	*0.023*	*11*	*7.4*	*5.1*	*4.2*
	Master:Mean	***all***	*0.16*	*1*	*1*	*1*	*1*	*0.22*	*0.21*	*0.32*	*0.36*
Ontario	Point Petre	EC EHD	0.076	-	-	-	-	7.8	5.7	5.6	6.2
	Point Petre	EC NWRI	0.043	0.036	0.06	0.11	0.055	11	11	3.7	4
	Burlington	EC EHD	0.002	-	-	-	-	16	19	12	9.5
	Metro Zoo (Toront	EC EHD	0.05	-	-	-	-	14	13	5.8	7.4
	Mean	***all***	*0.043*	*0.036*	*0.06*	*0.11*	*0.055*	*12*	*12*	*6.7*	*6.8*
	Master:Mean	***all***	*1.8*	-	-	-	-	*0.64*	*0.47*	*0.84*	*0.92*

Table E3: 1996 Annual Pesticide Concentrations in Air (pg/m^3)

Lake Basin	Station	Agency	Medium	α-HCH	dieldrin	*cis*-chlordane	*trans*-chlordane	*p,p'*-DDD	*p,p'*-DDE	*p,p'*-DDT	γ-HCH	α-endosulphan	β-endosulphan
Superior	Eagle Harbor	EPA/IU	XAD	78	9.8	3.4	2.4	0.86	1.6	2.8	16	24	1.7
	Brule River	EPA/IU	XAD	86	7.2	3.1	2	1.2	1	0.64	12	15	1.4
	Mean	***all***		***82***	***8.5***	***3.3***	***2.2***	***1***	***1.3***	***1.7***	***14***	***20***	***1.5***
	Master:Mean	***all***		***0.95***	***1.2***	***1***	***1.1***	***0.84***	***1.2***	***1.6***	***1.2***	***1.2***	***1.1***
Michigan	Sleeping Bear Dunes	EPA/IU	XAD	64	15	5.3	4.5	1.1	6.7	3.3	21	65	6.8
	IIT (Chicago)	EPA/IU	XAD	99	140	45	47	2.9	36	36	52	83	6.7
	Mean	***all***		***82***	***78***	***25***	***26***	***2***	***21***	***19***	***36***	***74***	***6.8***
	Master:Mean	***all***		***0.79***	***0.2***	***0.21***	***0.18***	***0.57***	***0.31***	***0.17***	***0.58***	***0.88***	***1***
Huron	Burnt Island	AES	PUF	30	7.7	2.1	1.8	0.13	1.9	0.6	9.3	10	1.2
Erie	Sturgeon Point	EPA/IU	XAD	67	18	8	6.8	1.9	15	14	30	77	6
Ontario	Point Petre	AES	PUF	32	11	4	3.4	0.38	11	5	15	58	12

Table E4: 1996 Annual HCB and PCB Concentrations in Air (pg/m^3)

Lake Basin	STATION	Agency	Medium	HCB	PCB18	PCB44	PCB52	PCB101
Superior	Eagle Harbor	EPA/IU	XAD	63	2.8	2.3	3.2	2.3
	Brule River	EPA/IU	XAD	70	3.4	3	3.9	2.1
	Mean	***all***	-	***66***	***3.1***	***2.6***	***3.5***	***2.2***
	Master:Mean	***all***	-	***0.95***	***0.91***	***0.86***	***0.89***	***1***
Michigan	Sleeping Bear Dunes	EPA/IU	XAD	65	5.5	5	5.3	3.1
	IIT (Chicago)	EPA/IU	XAD	100	61	110	80	52
	Mean	***all***	-	***84***	***33***	***59***	***43***	***27***
	Master:Mean	***all***	-	***0.78***	***0.16***	***0.085***	***0.12***	***0.11***
Huron	Burnt Island	AES	PUF	31	6.6	1.1	2	0.92
Erie	Sturgeon Point	EPA/IU	XAD	62	6.1	8.5	10	5.5
Ontario	Point Petre	AES	PUF	35	11	2.7	5.4	2.7

Table E5: 1996 Annual PAH Concentrations in Air (pg/m³)

Lake Basin	STATION	Agency	Medium	PHEN	PYR	B(k)F	B(a)P
Superior	Eagle Harbor	EPA/IU	GFF	18	18	9.4	8.2
	Brule River	EPA/IU	GFF	84	68	24	18
	Mean	***all***	-	***51***	***43***	***17***	***13***
	Master:Mean	***all***	-	***0.35***	***0.42***	***0.56***	***0.63***
Michigan	Sleeping Bear Dunes	EPA/IU	GFF	23	24	12	11
	IIT (Chicago)	EPA/IU	GFF	1000	2000	620	780
	Mean	***all***	-	*520*	*1000*	*320*	*400*
	Master:Mean	***all***	-	*0.045*	*0.023*	*0.038*	*0.027*
Huron	Burnt Island	AES	GFF	26	32	19	26
Erie	Sturgeon Point	EPA/IU	GFF	100	140	76	65
Ontario	Pt Petre	AES	GFF	52	72	58	57

Appendix F: Annual Mass Fluxes to the Great Lakes from 1992 to 1996

Figure F1: Annual Average Wet Deposition Flux ($ng/m^2/d$) of Organochlorine Pesticides

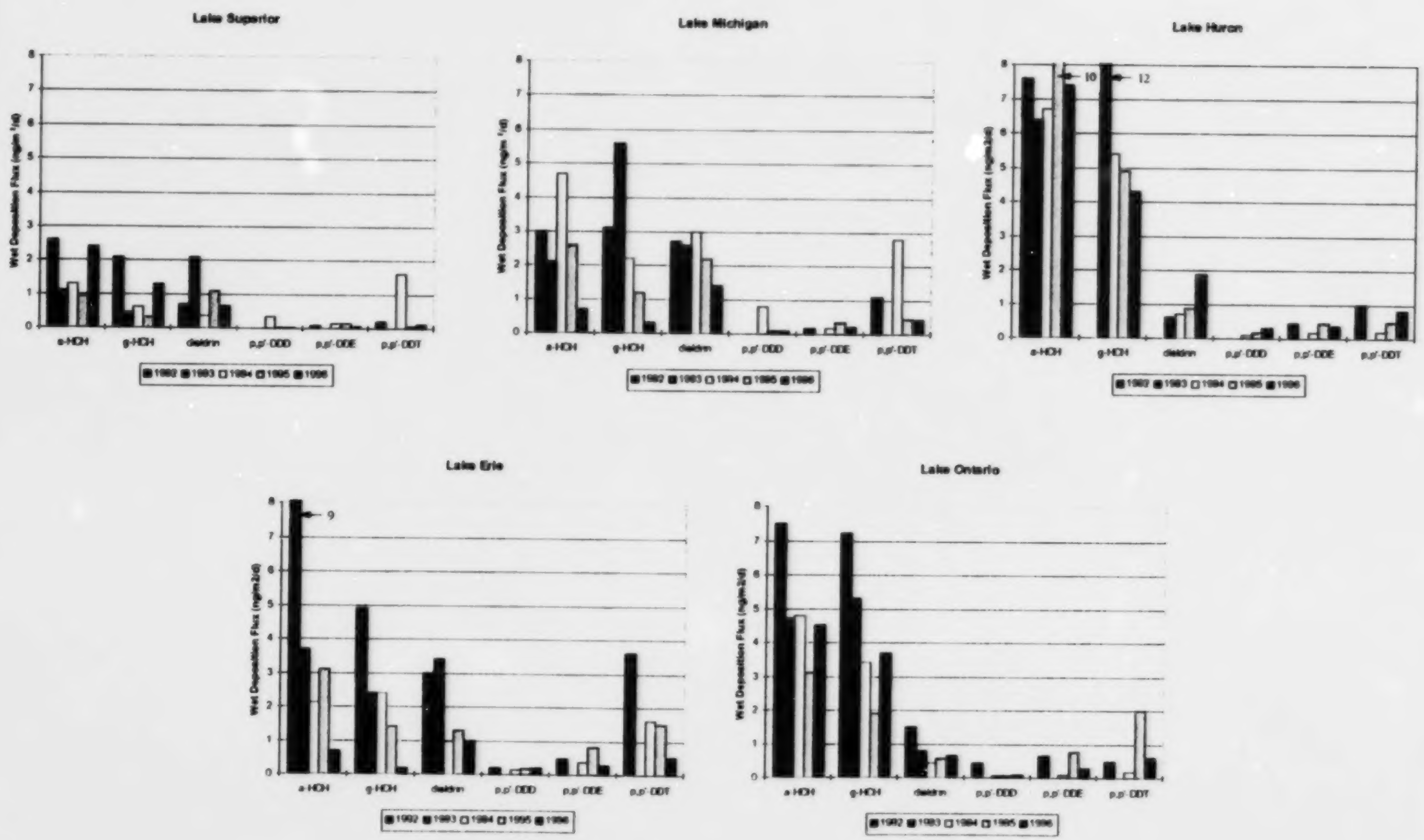
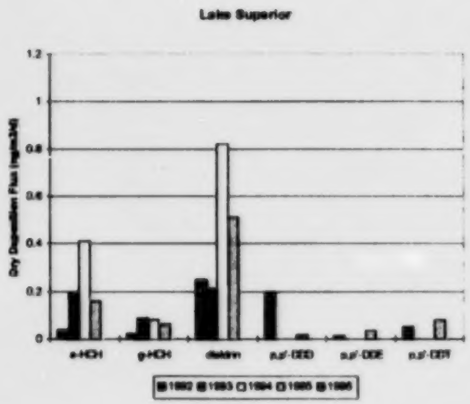
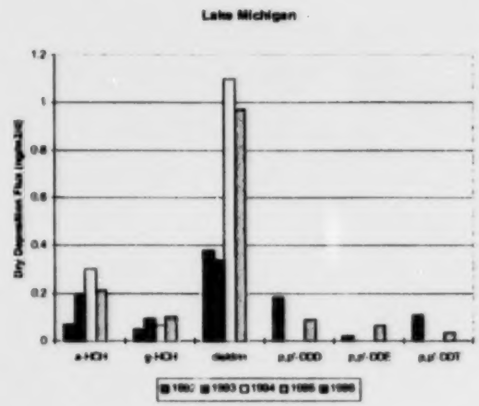
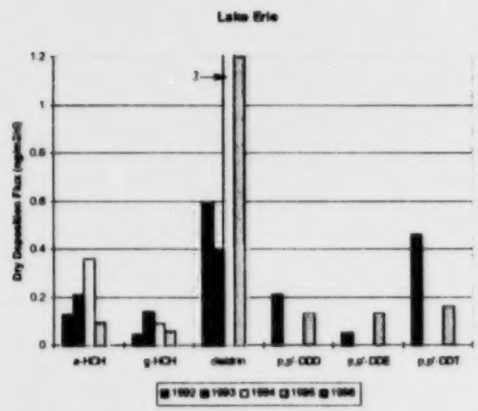


Figure F2: Annual Average Dry Deposition Flux ($ng/m^2/d$) of Organochlorine Pesticides





Data not available for Lake Huron



Data not available for Lake Ontario

Figure F3: Annual Average Net Gas Exchange Flux ($ng/m^2/d$) of Organochlorine Pesticides (Positive values denote net gas absorption, negative values denote net volatilisation)

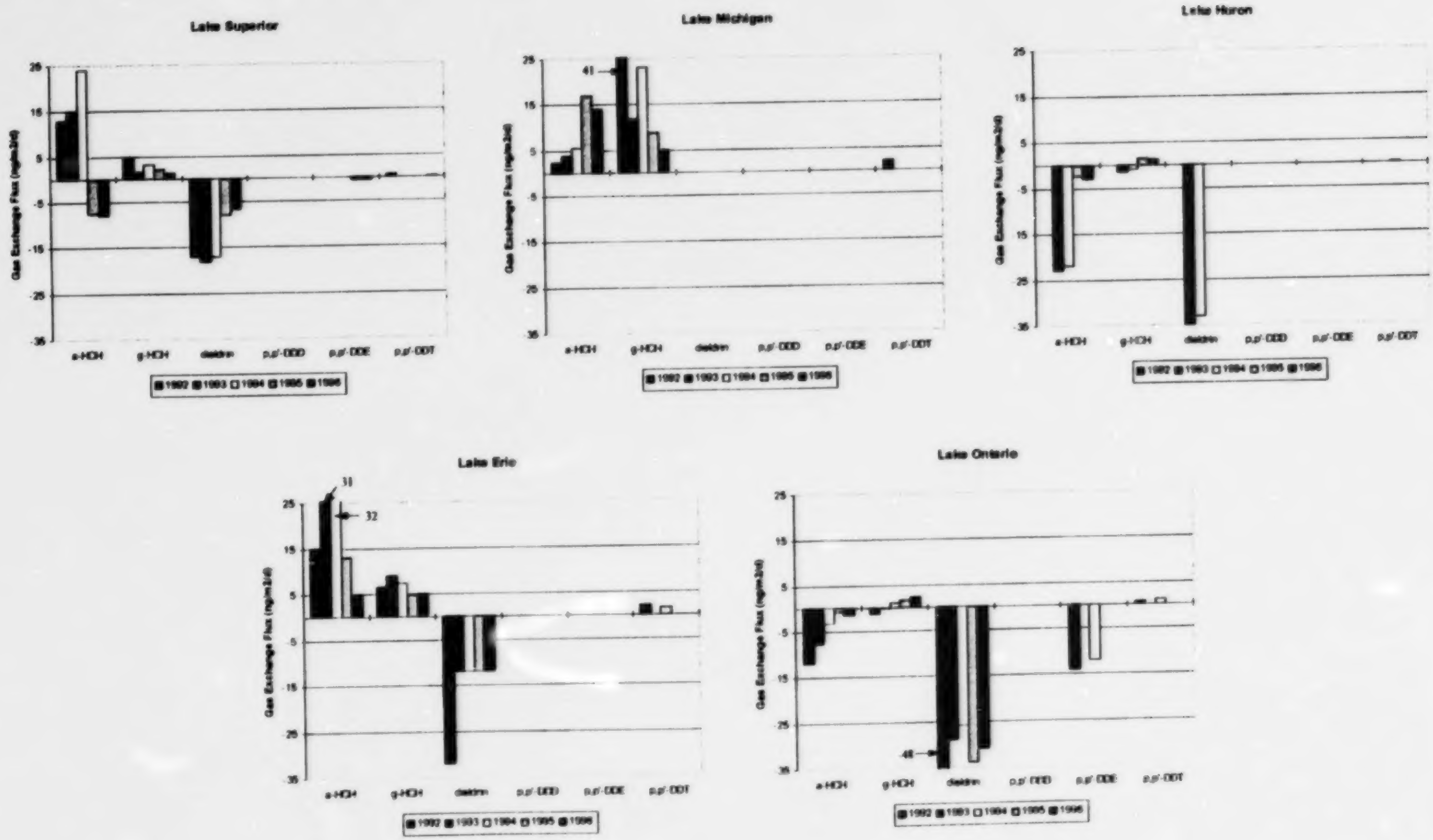


Figure F4: Annual Average Wet Deposition Flux ($ng/m^2/d$) of PCBs

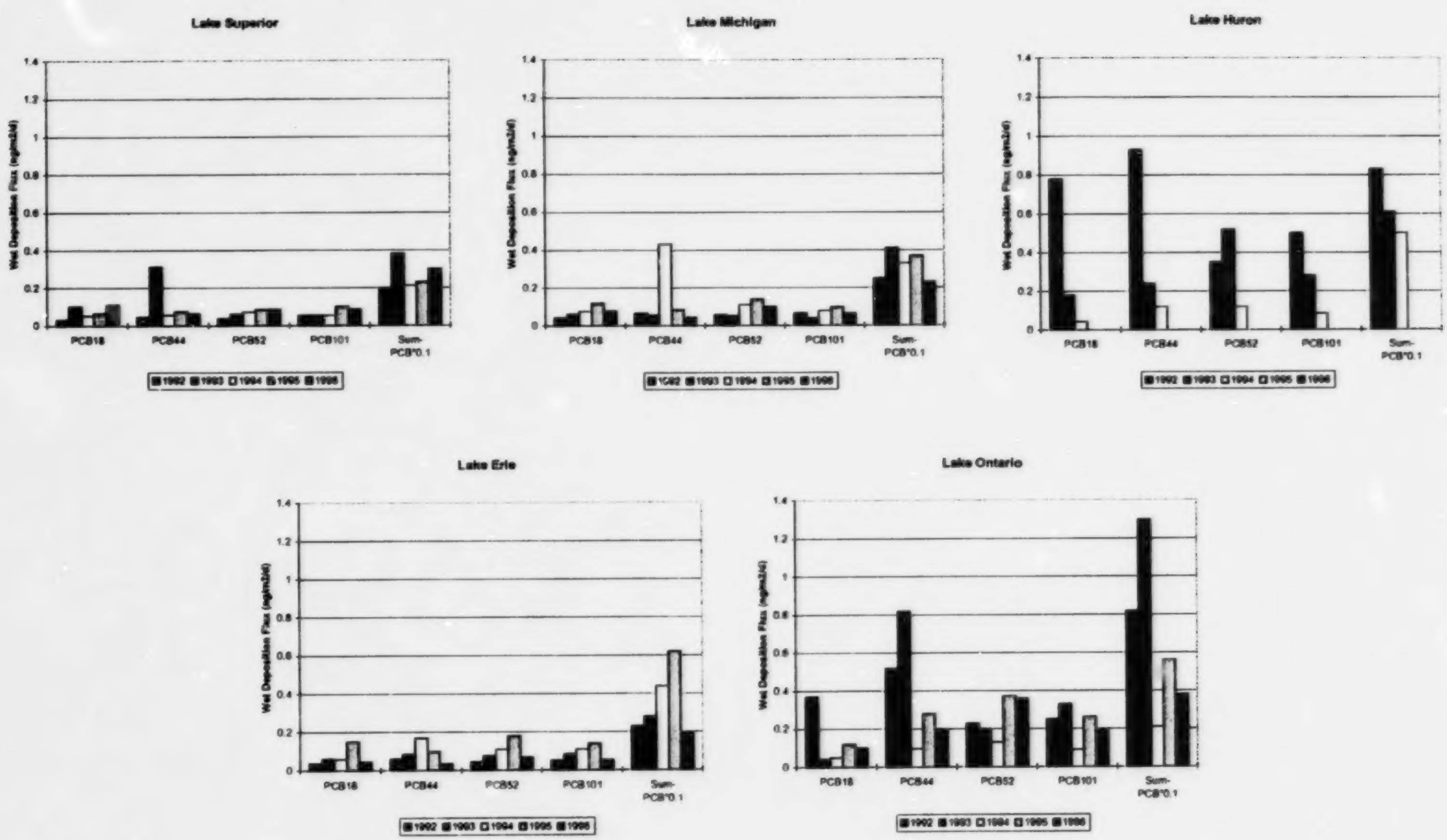
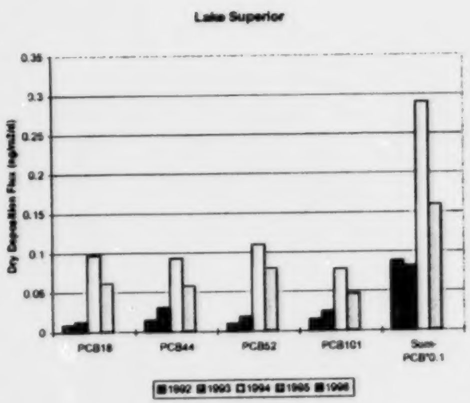
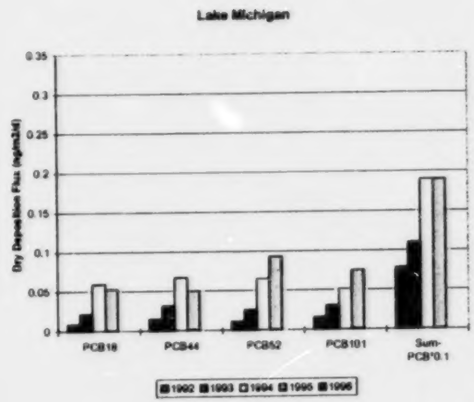
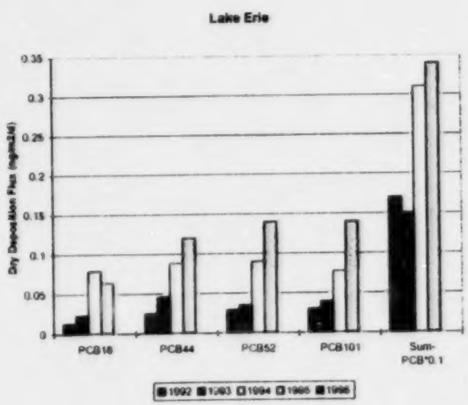


Figure F5: Annual Average Dry Deposition Flux ($ng/m^2/d$) of PCBs



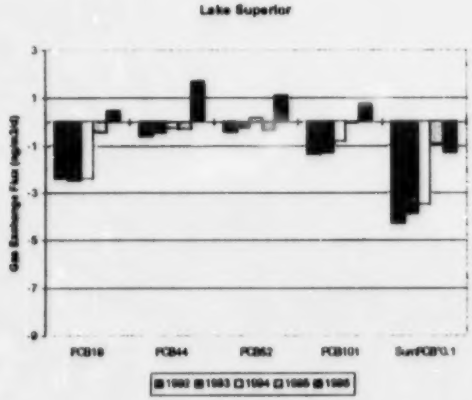


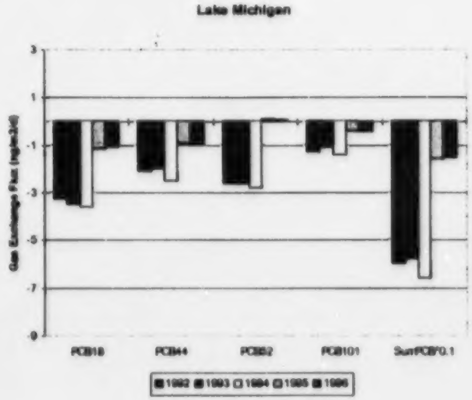
Data not available for Lake Huron

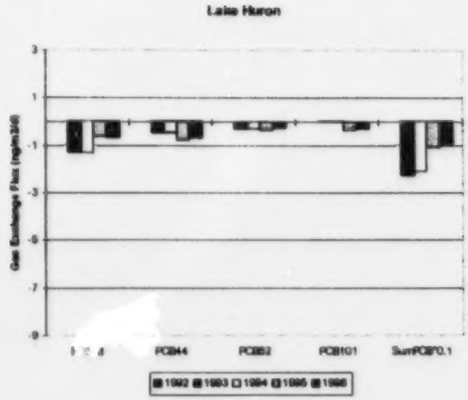


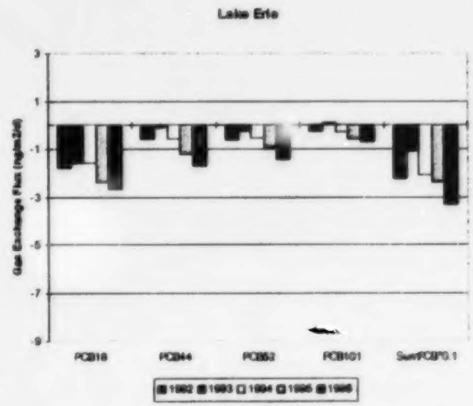
Data not available for Lake Ontario

Figure F6: Annual Average Net Gas Exchange Flux (ng/m^2/d) of PCBs
(Positive values denote net gas absorption, negative values denote net volatilisation)









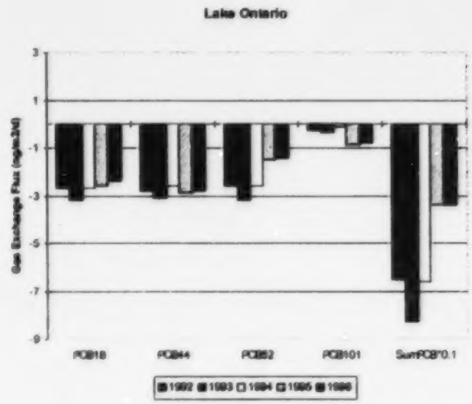


Figure F7: Annual Average Wet Deposition Flux (ng/m^2/d) of PAHs
** 1992 -1994: B(b)F; 1995 - 1996: B(b+k)F*

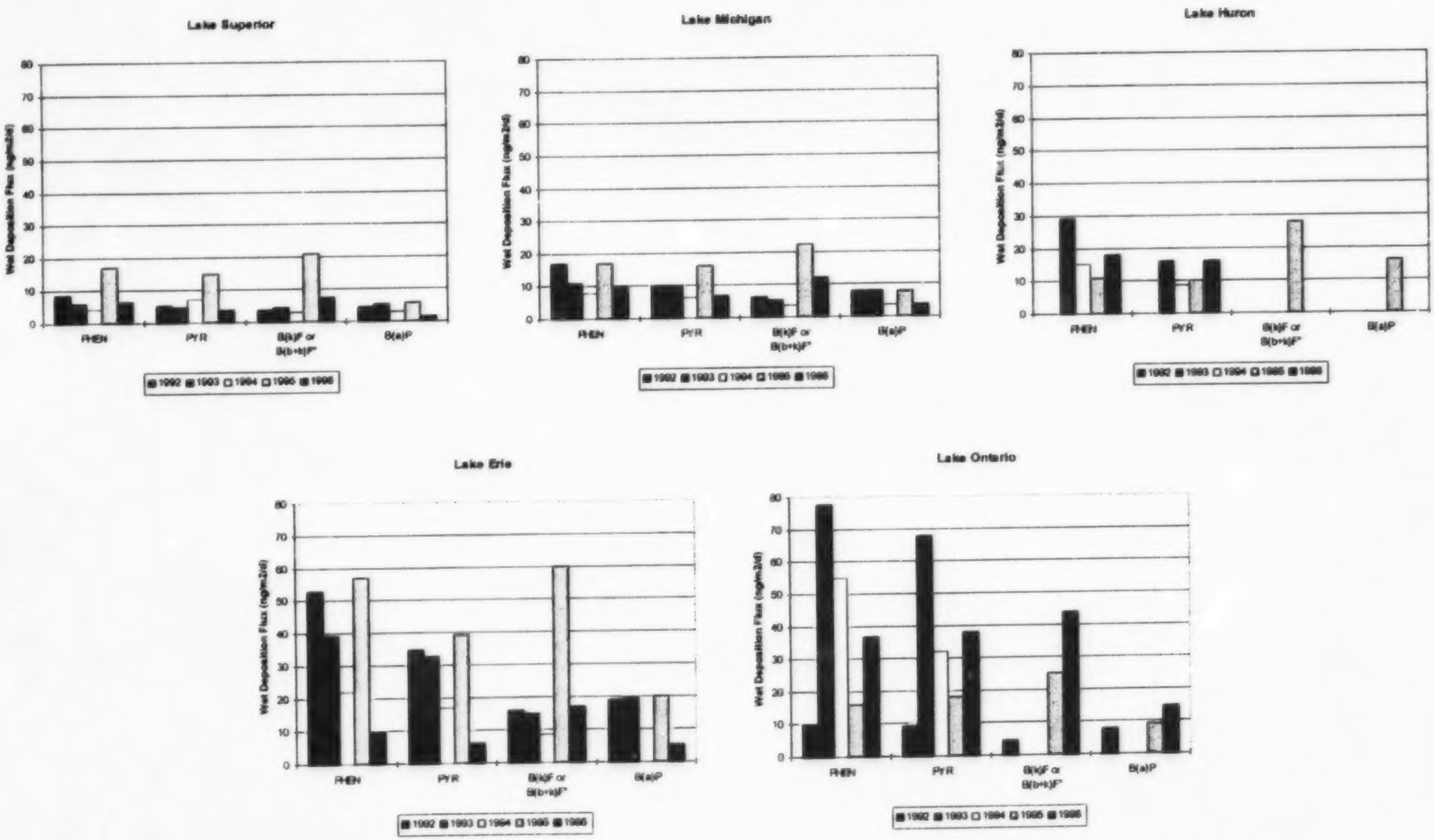


Figure F8: Annual Average Dry Deposition Flux ($ng/m^2/d$) of PAHs

** 1992 -1994: B(b)F; 1995 - 1996: B(b+k)F*

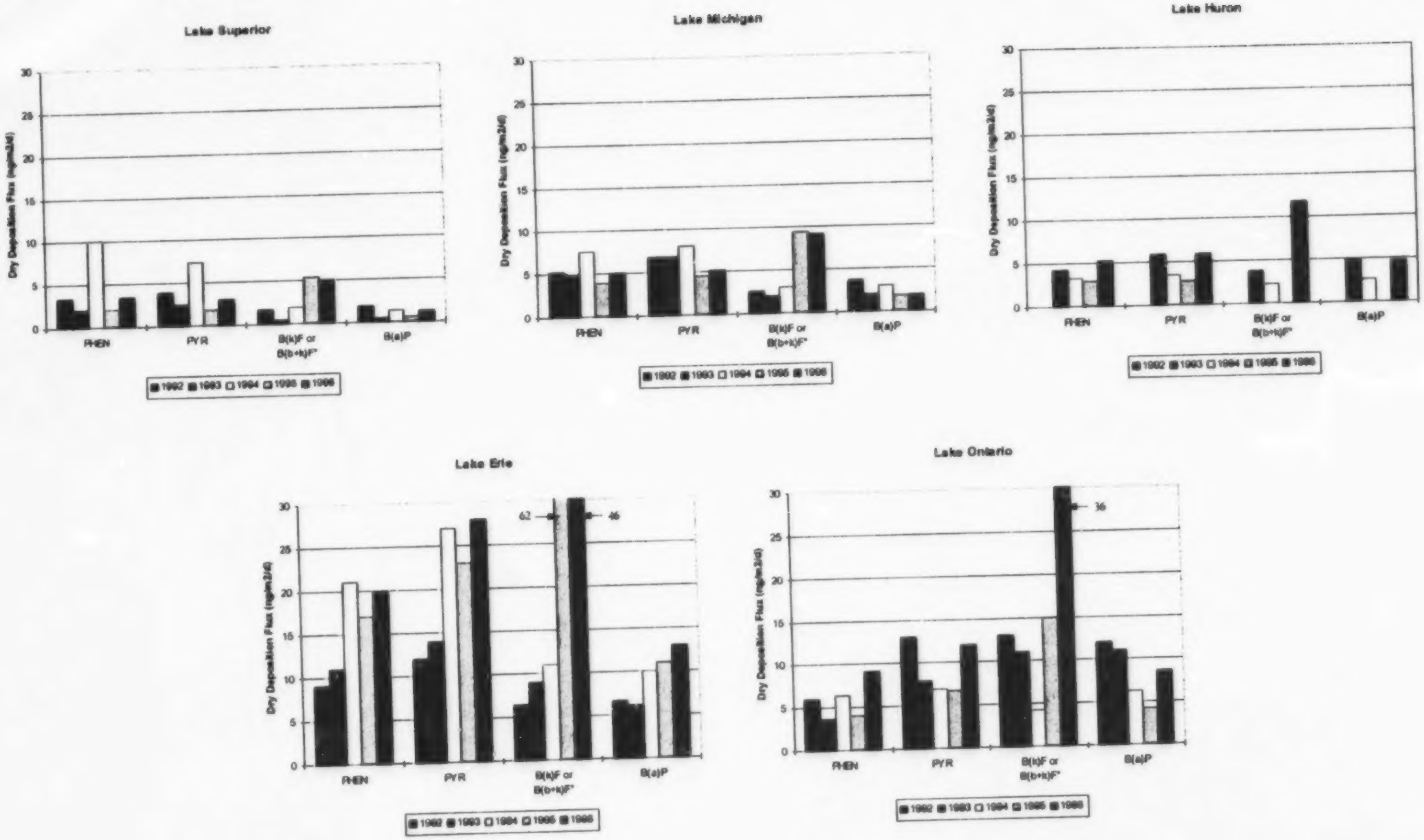
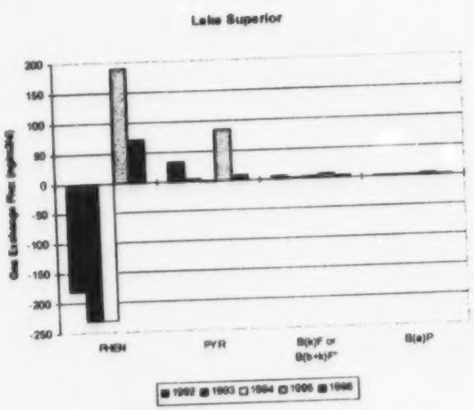
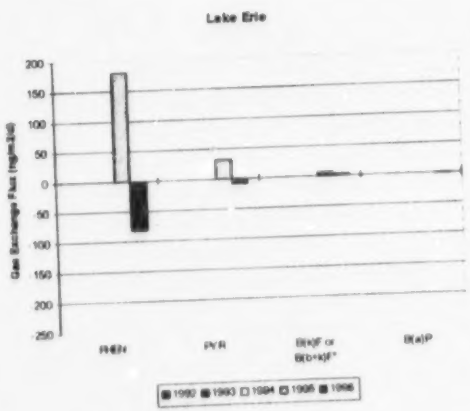


Figure F9: Annual Average Net Gas Exchange Flux ($ng/m^2/d$) of PAHs
(Positive values denote net gas absorption, negative values denote net volatilisation) * *1992 -1994: B(b)F; 1995 - 1996: B(b+k)F*



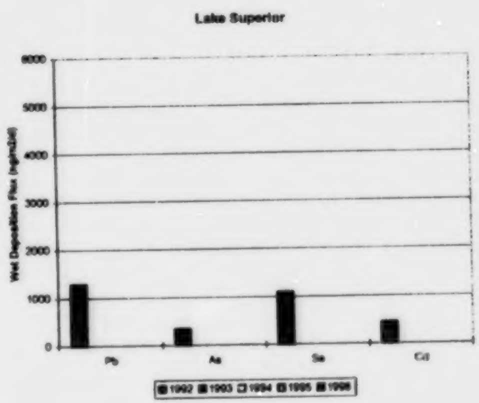
Data not available for Lake Michigan

Data not available for Lake Huron

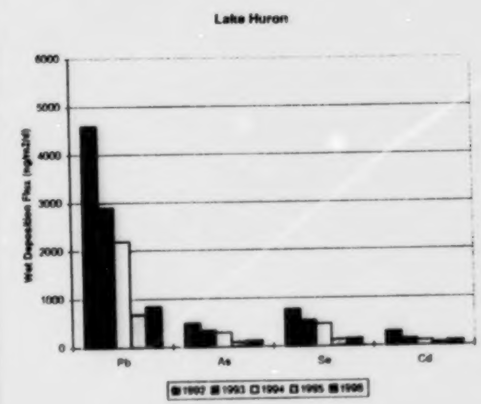


Data not available for Lake Ontario

Figure F10: Annual Average Wet Deposition Flux (ng/m^2/d) of Metals



Data not available for Lake Michigan



Data not available for Lake Erie

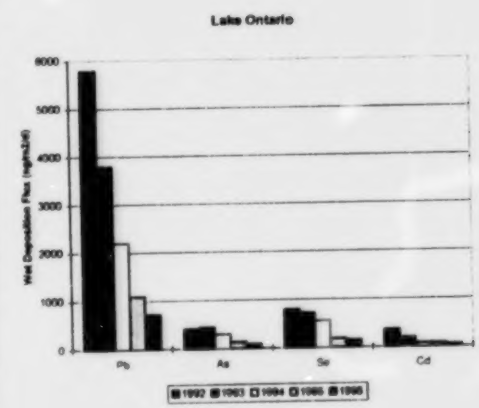


Figure F11: Annual Average Dry Deposition Flux ($ng/m^2/d$) of Metals